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NURP (Nationwide Urban Runoff Program)
Priority Pollutant Monitoring Project
Summary of Findings

Dalton-Dalton-Newport, Inc., Cleveland, OH

Prepared for

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The Nationwide Urban Runoff Program (NURP) priority pollutant monitoring project was initiated to evaluate the presence, concentrations, and potential water quality impacts of priority pollutants in urban stormwater runoff. From 1980 to 1983, 121 runoff samples were collected from 61 predominately residential and commercial sites across the country and analyzed for 127 of the 129 priority pollutants. Seventy-seven priority pollutants were detected, which included 14 inorganic and 63 organic pollutants. Lead and selenium were the inorganic priority pollutants which could represent a potential risk to humans in undiluted runoff. The organic priority pollutants with this potential were two BHC isomers, both pesticides. Dilution, settling, and other fate processes in receiving waters as well as treatment of water supplies tend to make the risk to humans small. The risk to aquatic life from priority pollutant metals is of more concern. Levels of cadmium, copper, lead, and zinc in undiluted runoff exceeded the EPA 1980 acute criteria for protection of aquatic life by a factor of 2 to 8. Consequently, these pollutants could cause harm to aquatic life, depending upon receiving stream dilution, storm duration, and whether the metal was in the more toxic soluble form.

A further evaluation of the forms of metals in urban runoff in the NURP special metals project revealed that about 40 percent of copper and zinc were in the soluble form, which is generally the most toxic form of the metals to aquatic life. No priority pollutant organics and only a few inorganics were consistently found at concentrations greater than their acute criteria of aquatic toxicity values in undiluted runoff.

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Surface water runoff
Drainage
Rainfall
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Surface Water
Watersheds
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NURP PRIORITY POLLUTANT MONITORING PROJECT

SUMMARY OF FINDINGS

December 12, 1983

U.S. Environmental Protection Agency
Monitoring and Data Support Division
Mr. Rod Frederick, Project Officer
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i.a

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CONTENTS

	Page
List of Figures	iii
List of Tables	iii
Preface	v
Abstract	vi
Acknowledgment	viii

Section

1.	Introduction	1
2.	Methodology	3
	The Sampling Program	3
	Data Compilation Methodology	6
	Data Analysis	8
3.	Quality Control	9
	Quality Control Approach	9
	Quality Control Evaluation Methods	10
	Special Cases	15
	Findings of the QC Evaluation	16
	Discussion of Quality Control Evaluation Findings	20
4.	Findings	23
	Pollutants Detected in Runoff	23
	Pollutants Not Detected in Runoff	37
	Results Not Valid	37
	Pollutants Not Included in NURP	36
	Other Pollutants	36
5.	Conclusions	40
	Potential Risks to Human Health	40
	Potential Risks to Aquatic Life	45
6.	Special Metals Sampling Project	47
	Introduction	47
	Methodology	49
	Findings	54
	Conclusions	63

References 66

Appendices

Appendix A - Land Use Characteristics of NURP Priority Pollutant Sites

CONTENTS (Continued)

Appendices (Continued)

Appendix B - Summary of EPA Ambient Water Quality Criteria
Appendix C - EPA Memorandum on Method Detection Limits
Appendix D - EPA Water Quality Criteria and Standards for Toxic Metals
Appendix E - Special Metals Quality Control Data

FIGURES

Number		Page
1	NURP Priority Pollutant City Locations . . .	5
2	NURP Categorization of 129 Priority Pollutants	28
3	NURP Special Metals City Locations	51

TABLES

1	NURP Cities Collecting Priority Pollutant Samples.	4
2	QC Decision Matrix for Blank Sample Results.	12
3	QC Decision Matrix for Performance Evaluation Sample Results.	14
4	Summary of Performance Evaluation Results. .	17
5	Summary of QC Evaluation of NURP Priority Pollutant Data Base for 128 Priority Pollutants	20
6	Summary of Analytical Chemistry Findings from NURP Priority Pollutant Samples	24
7	Most Frequently Detected Priority Pollutants in NURP Urban Runoff Samples	29
8	Range of Geometric Means for Pollutants Found at Least 20% of the Time	30
9	Summary of Water Quality Criteria Exceedances for Pollutants Detected in at Least 10 Percent of NURP Samples: Percentage of Samples in Which Pollutant Concentrations Exceed Criteria	32
10	Infrequently Detected Priority Pollutants in NURP Urban Runoff Samples	34
11	Non-Priority Pollutants Reported in NURP Urban Runoff Samples	39
12	Predominant Sources of Priority Pollutants Which Have Been Detected in at Least 10 Percent of Urban Runoff Samples.	41

TABLES (Continued)

Number Page

13 Special Metals Project: Parameter List. . . 48

14 NURP Cities Participating in the Special Metals Sampling Project. 40

15 Summary of Analytical Procedures Used in the Special Metals Sampling Program . . . 53

16 Summary of Number of Detections, Mean Concentrations, Range and Detection Limits for Special Metals Data Collected from March 1981 to June 1982 55

17 Summary of Water Quality Criteria Violations 59

18 Total Recoverable and Dissolved Metals Concentration as a Percent of Total Metals Concentration: Priority Pollutant Metals 60

19 Total Recoverable and Dissolved Metals Concentration as a Percent of Total Metals Concentration: Non-Priority Pollutant Metals 61

20 Summary of Violation of EPA's "Red Book" Criteria for Non-Priority Pollutant Metals . 64

PREFACE

The U.S. Environmental Protection Agency, Office of Water Regulations and Standards (OWRS), is conducting programs to evaluate the environmental hazards posed by priority pollutants in our nation's waters. The Monitoring and Data Support Division of OWRS is coordinating a program to determine the significance of urban runoff as one source of toxic pollutants to receiving waters. Specifically, the objective of this program, the Nationwide Urban Runoff Program (NURP) priority pollutant monitoring project, is to make a preliminary assessment of which priority pollutants are found in urban stormwater runoff, how often, at what concentrations, and with what potential impacts.

The special metals sampling project is an additional effort designed to enhance the usefulness of the NURP priority pollutant data base for metals, which are the pollutants most frequently associated with urban stormwater runoff. The primary objective of the special metals project is to determine the relationships among dissolved, total, and total recoverable concentrations of selected metals in runoff waters.

The information developed through these efforts will permit identification of problem areas nationwide and the subsequent development of the most effective mitigation strategies to correct urban runoff related problems. This report documents findings and results from the NURP priority pollutant and special metals monitoring projects as of September 1983.

ABSTRACT

The Nationwide Urban Runoff Program (NURP) priority pollutant monitoring project was initiated to evaluate the presence, concentrations, and potential water quality impacts of priority pollutants in urban stormwater runoff. From 1980 to 1983, 121 runoff samples were collected from 61 predominantly residential and commercial sites across the country and analyzed for 127 of the 129 priority pollutants. The results from this NURP effort cannot, therefore, be attributed to runoff from industrial facilities or complexes.

Monitoring data were tabulated and summarized, and undiluted pollutant concentrations were compared to EPA water quality criteria, drinking water standards, and toxicity levels. Seventy-seven priority pollutants were detected, which included 14 inorganic and 63 organic pollutants. Lead and selenium were the inorganic priority pollutants which could represent a potential risk to humans in undiluted runoff. The organic priority pollutants with this potential were α-hexachlorocyclohexane (α-BHC) and γ-hexachlorocyclohexane (γ-BHC), both pesticides. Dilution, settling, and other fate processes in receiving waters as well as treatment of water supplies tend to make the risk to humans small. The risk to aquatic life from priority pollutant metals is of more concern. Levels of cadmium, copper, lead, and zinc in undiluted runoff exceeded the EPA 1980 acute criteria for protection of aquatic life by a factor of 2 to 8. Consequently, these pollutants could cause harm to aquatic life, depending upon receiving stream dilution, storm duration, and whether the metal was in the more toxic soluble form.

A further evaluation of the forms of metals in urban runoff in the NURP special metals project revealed that about 40 percent of copper and zinc were in the soluble form, which is generally the most toxic form of metals to aquatic life. Virtually none of the lead was in soluble form, while results for cadmium in the various forms could not be obtained due to limited data.

Although no priority pollutant organics and only a few inorganics were consistently found at concentrations greater than their acute criteria or aquatic toxicity

values in undiluted runoff, there is still little information available on the accumulation of low concentrations of persistent priority pollutants in sediments or on the long term effects of these substances on aquatic life and human health.

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SECTION 1

INTRODUCTION

The Nationwide Urban Runoff Program (NURP) priority pollutant monitoring project was initiated to evaluate the significance of priority pollutants in urban stormwater runoff. The principal objectives of the program are (1) to determine which priority pollutants are found in urban stormwater runoff, how frequently, and at what concentrations, and (2) to evaluate the potential impacts of priority pollutants carried by urban runoff on aquatic life and water supplies. The information generated by this program will allow the Office of Water Regulations and Standards (OWRS) of the Environmental Protection Agency (EPA) to assess the significance of urban runoff relative to other point and non-point sources of toxic pollutants, in order to develop the most efficient and cost-effective control strategies.

The priority pollutants are a group of toxic chemicals or classes of chemicals listed under Section 307(a)(1) of the Clean Water Act of 1977 (PL 95-217, U.S.C. 466 et seq.). There are ten major groups of priority pollutants including 129 specific compounds or classes of compounds.

The NURP priority pollutant monitoring program was developed by the Water Planning Division of EPA which provided grants to various urban localities for sample collection and laboratory analysis. EPA's Monitoring and Data Support Division (MDSD) provided technical guidance concerning sampling and analysis procedures, quality assurance and quality control, processing of data, and interpretation of results. The NURP priority pollutant program was developed as a logical extension of the NURP conventional pollutant program, which is primarily concerned with measuring concentrations of conventional pollutants such as solids, phosphorus, nitrogen, and nitrates in urban runoff.

Sampling activity across the country has now been completed. This report summarizes the results from field sampling and quality control, based on data which were available as of September 30, 1983, and offers tentative conclusions regarding program objectives.

This report is organized into the following sections:

Section 1 - Introduction
Section 2 - Methodology
Section 3 - Quality Control
Section 4 - Findings
Section 5 - Conclusions
Section 6 - Special Metals Sampling Project

SECTION 2

METHODOLOGY

THE SAMPLING PROGRAM

Twenty cities and metropolitan councils of government (hereafter all will be referred to simply as "cities") agreed to participate in the NURP priority pollutant monitoring program (Table 1). The geographical distribution of these cities includes 12 of the 18 major river basins in the continental United States (Figure 1), and ensures that a variety of climatic regimes and soil types are represented in the sample population.

Samples have been collected from 61 catchments which include a varied range of sizes, populations, and land use types (Appendix A). The largest catchment, for example, collects runoff from 33,544 acres, the smallest from a single acre. The most common land use types are low-density residential, medium-density residential, and commercial. A limited number of industrial land uses are included, although these are primarily industrial parks. Land use characteristics of the sampling sites were obtained and recorded for use in future analyses, which will attempt to relate toxics concentrations and loadings to site-specific land use and topographic characteristics.

MDSD developed general guidelines for site selection and sample collection to ensure that a consistency of approach was employed by the participating cities, each of which was also investigating runoff issues of particular local interest. The following general guidelines were issued to be complied with whenever possible:

1. Use sites for priority pollutant sampling which are also being used for NURP conventional pollutant sampling.

2. Use sites which have no base flow.

3. Take a flow composite sample for the entire storm event. Discrete samples may also be taken and used to examine concentration variations during the storm event, and for volatiles and cyanides determinations.

TABLE 1.

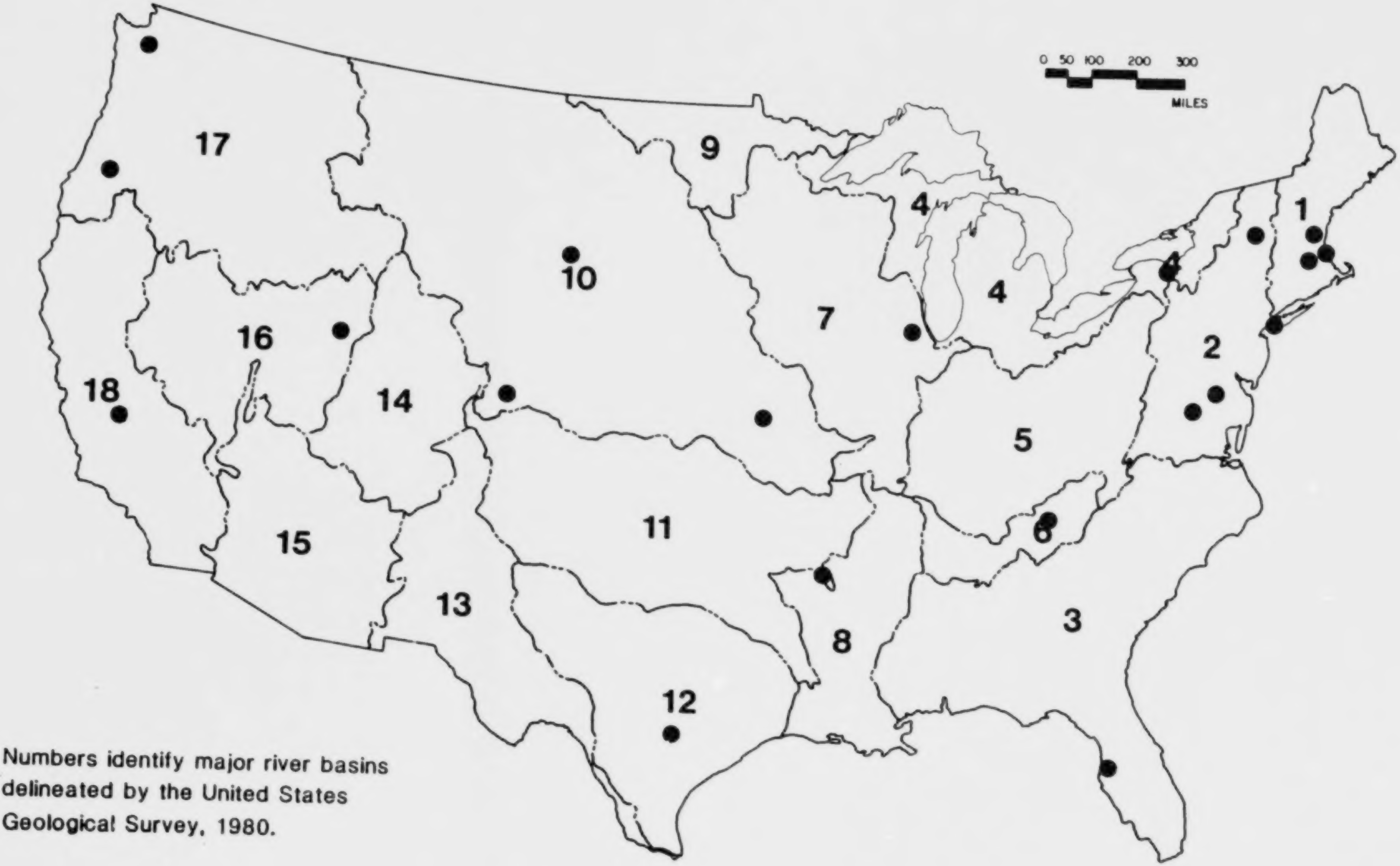
NURP CITIES COLLECTING PRIORITY POLLUTANT SAMPLES[a]

*1. Durham, New Hampshire
*2. Lake Quinsigamond, Massachusetts
*3. Mystic River, Massachusetts
*4. Long Island, New York
5. Lake George, New York
6. Irondequoit Bay, New York
*7. Metro Washington, D.C.
*8. Baltimore, Maryland
11. Tampa, Florida
*12. Knoxville, Tennessee
*17. Glen Ellyn, Illinois
*19. Austin, Texas
*20. Little Rock, Arkansas
*21. Kansas City, Kansas
*22. Denver, Colorado
*23. Salt Lake City, Utah
*24. Rapid City, South Dakota
*26. Fresno, California
*27. Bellevue, Washington
*28. Eugene, Oregon

---

* Asterisk indicates cities from which priority pollutant analytical data and required quality control information were available as of 9/30/83.

[a] Numbering system conforms to NURP convention; some cities are omitted as not all NURP cities are collecting priority pollutant samples.


0 50 100 200 300
MILES
1
2
3
4
4
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Numbers identify major river basins delineated by the United States Geological Survey, 1980.

● : Priority Pollutant City

Figure 1. NURP Priority Pollutant City Locations.

More detailed guidance was provided early in the program at an MDSD-sponsored workshop held in Springfield, Virginia. This workshop covered such issues as container selection, container preparation, sample preservation, shipping procedures, modification of conventional sampling equipment for the collection of priority pollutant samples, and other topics. All participants received a copy of the guidance manual, "Monitoring of Toxic Pollutants in Urban Runoff" (Versar, 1980a). A detailed account of MDSD guidance is too lengthy to be included here, but can be obtained from the many sources listed in the References section of this report.

Each NURP participant provided for the laboratory analysis of its own priority pollutant samples. Approximately one-third of the cities arranged for such services through the EPA Sample Control Center, which agreed to coordinate laboratory services for any cities which so desired. The remaining cities contracted directly with independent laboratories. Quality assurance (QA) procedures were established to ensure that the data developed from these many cities and laboratories would be of high quality. Quality control activities are discussed in Section 3 of this report.

MDSD recommended that two pollutants, asbestos and TCDD (dioxin), not be included in the NURP program. Asbestos was excluded due to high analytical costs. Dioxin was excluded due to the potential health risks its toxicity poses to laboratory personnel.

At the time of preparation of this report, priority pollutant analytical data and required quality control information were available from 17 cities: Durham, New Hampshire; Lake Quinsigamond, Massachusetts; Mystic River, Massachusetts; Long Island, New York; Washington, D.C.; Baltimore, Maryland; Knoxville, Tennessee; Glen Ellyn, Illinois; Austin, Texas; Little Rock, Arkansas; Kansas City, Kansas; Denver, Colorado; Salt Lake City, Utah; Rapid City, South Dakota; Fresno, California; Bellevue, Washington; and Eugene, Oregon. Some 121 samples have been collected and analyzed, with results available for both the organic and inorganic priority pollutants.

DATA COMPILATION

The NURP data will provide a first comprehensive, national look at the priority pollutant content of urban runoff. Accordingly, a complete and clear tabulation of this unique data base must be made. To do so, observed pollutant concentrations were first subjected to quality control review, and either accepted without qualification, with qualification, or rejected. Summaries of the monitoring data for each pollutant were then prepared. These summaries include the range of detected concentrations, frequency of detection, cities where the pollutant was found; and for selected pollutants, the mean concentration and exceedances of water quality criteria. Some clarification of these statistics is helpful and is given below.

The range of detected concentrations gives the minimum and maximum detected concentrations of the pollutant. If either of these values is qualified by a quality control remark code, this is reported also. A single value indicates only one positive observation, or that all detected concentrations were equal.

The geometric mean of all observations was calculated only if the pollutant was detected in at least 20 percent of the NURP samples, in order to provide a sufficient number of positive results to make this statistic meaningful. The geometric mean rather than the arithmetic mean was used, as this is the appropriate measure of central tendency when data are log-normally distributed. Such a distribution of runoff data has been demonstrated in the draft EPA Water Planning Division report "Preliminary Results of the NURP Program" (Athayde et al., 1982), and other runoff studies.

Calculating an exact value for the mean (geometric or arithmetic) is impossible, however, when some results are "not detected" or "below detectable limits" and therefore unquantified. What can be done in this case is to calculate two geometric means which determine a range within which the actual mean should fall. The upper end of this range is calculated by substituting the reported (or nominal) analytical detection limit in the case of an undetected result. The lower end is calculated by substituting one tenth of the detection limit for an undetected result. The value zero is not used because it cannot be accommodated in geometric mean calculations.

The frequency of detection is a key parameter for the NURP priority pollutant data analysis. Frequency of detection is the number of times detected divided by the number of acceptable samples, i.e., all those not withdrawn for quality control reasons. The number of times detected, in turn, is the number of positive results, including all values with any quality control code except "U" (for undetected).

Criteria exceedances are indicated when the maximum reported pollutant concentration exceeds EPA water quality criteria or standards (Appendix B). Criteria for the protection of aquatic life and human health and welfare are used. Criteria for the protection of aquatic life are of two types: (1) the freshwater "acute" criterion, the maximum concentration of a pollutant permitted at any time; and (2) the freshwater "chronic" criterion, the maximum 24-hour average concentration allowed. If either the acute or chronic criterion has not been established for a pollutant, then the lowest reported freshwater acute concentration or the lowest reported freshwater chronic concentration, as reported in the 1980 ("White Book") criteria documents, is substituted. Human health criteria include both a non-carcinogenic health criterion for the ingestion of contaminated water and organisms, and carcinogenic effects criteria at the 10^{-5}, 10^{-6}, and 10^{-7} risk levels for ingestion of contaminated water and organisms. Human health criteria based on the ingestion of contaminated organisms only were not used in order to apply the more stringent water and organisms criteria. EPA criteria associated with taste and odor problems (organoleptic criteria) and drinking water standards under the Safe Drinking Water Act were also considered.

DATA ANALYSIS

The thrust of data analysis at this stage is to make an initial identification of those priority pollutants whose presence and concentrations in urban runoff appear to pose the greatest threat to surface water quality, and to evaluate the extent of this potential threat. The limited size of the data base and the constraints imposed by the variety of individual sampling programs and analytical laboratories suggests that current results should be accepted as an initial but not definitive identification or quantitation of the priority pollutants found in urban runoff.

The first phase of this identification and screening process examines frequencies of detection, to separate pollutants which occur frequently from those which are found rarely or not at all. Those pollutants found most frequently are further evaluated, particularly with respect to their reported concentrations. These concentrations are compared to water quality criteria to relate the reported levels to levels at which degradation of water quality may begin to occur. Finally, the "Conclusions" section identifies the major sources of the most significant pollutants and discusses the implications of the findings concerning the protection and maintenance of water quality.

SECTION 3

QUALITY CONTROL

QUALITY CONTROL APPROACH

This section describes the results of the quality control evaluation of the analytical data generated by the NURP program. An explanation of the entire quality assurance/quality control plan can be found in the "Quality Assurance Project Plan for the Priority Pollutant Section of the Nationwide Urban Runoff Program" (EPA, 1982). The exacting demands of priority pollutant laboratory analysis, in conjunction with the low pollutant concentrations found in urban runoff, have made the generation of reliable data a difficult task, one in which the role of QA/QC is emphasized. This section considers only the quality control of the NURP priority pollutant laboratory data and does not cover quality assurance or other topics important to data generation, such as site selection or sampling schedules.

Quality control (QC) evaluation is essential in any data collection program, for only through this process can the validity of the data be established. Data must withstand rigorous scrutiny of all aspects of its generation in order to be considered accurate, precise, complete, comparable to data generated on other projects or collected at different times, and legally and scientifically defensible. In a QC evaluation, data are subjected to several tests, beginning with those of a general nature and proceeding to the more detailed and specific. Through the application of these tests, the relative quality of the data can be established.

QC evaluation requires a large body of test results and corroborating information to verify every aspect of the quality of the data, including information on sampling equipment, sampling technique, shipping procedures, sample holding times, laboratory procedures, field and method blanks, replicate samples, performance evaluation results, surrogate and spiked samples, and matrix effects. Indeed, a fully rigorous approach to QC review would assume that the data are invalid unless it can be shown that all relevant facets of their generation met the appropriate quality assurance requirements. In practice, all of this information is not available for all cities and laboratories involved in the NURP priority pollutant project, and QC activities were of necessity limited by the supporting information available.

If QC data were incomplete or missing, special efforts were made to obtain the necessary information. These efforts were usually but not always successful. If not, it was assumed for purposes of this project that data were valid in cases where no information indicated otherwise. As long as the data appeared reasonable, it was assumed that field and laboratory practices were consistent with established project guidelines. This approach was taken in order to retain as much useful NURP data as could be justified. Although this results in a lower level of confidence in the data than a more stringent QC evaluation, it allows a large data base to be retained of sufficient quality for "first-cut" screening purposes.

The remainder of this section discusses the most important methods used in the QC evaluation, findings of the QC evaluation, and related QC issues.

QUALITY CONTROL EVALUATION METHODS

Given below are the most important methods used to perform the QC evaluation of the NURP data. Additional information on these methods can be found in the "Quality Assurance Project Plan for the Priority Pollutant Section of the Nationwide Urban Runoff Program" (EPA, 1982).

Holding Time Exceedances

The Federal Register (FR) specifies maximum holding times for priority pollutant sample analysis, assuming proper preservation (44FR 69464 and 75028, December 3 and 18, 1979, proposed rules). Holding times for inorganics are six months, except for mercury and cyanides. The limit for mercury is 28 days from date of collection to date of analysis. The limit for cyanides is only 14 days. However, all cyanides results were accepted even though the relevant dates were not always available.

For organics, the time limits specified in the FR could not be achieved for all samples. Discussions with personnel from EPA's Effluent Guidelines Division about this problem indicated that some relaxation of the organics holding time requirements could be tolerated without an undue risk to the reliability of the data. Accordingly, the following revised standards were used:

- Semi-volatiles - 14 days from date of collection to date of extraction (FR specifies 7 days from date of collection to date of extraction and 30 days from date of extraction to date of injection)
- Volatiles - 3 days from date of collection to date of receipt by laboratory, and 22 days from date of receipt by laboratory to date of injection (FR specifies 14 days from date of collection to date of extraction and injection; for acrolein and acrylonitrile, the limit is 3 days)

A list of the pollutants in each of the organic pollutant fractions can be found in "Quality Assurance for Laboratory Analysis of 129 Priority Pollutants" (Versar, 1980b). The above criteria were applied whenever the information necessary to evaluate holding times was available. Complete information on holding periods was available roughly two-thirds of the time, partial information the remaining third of the time. In cases where the information was not available, and attempts to obtain the necessary information failed, the sample was conditionally accepted.

Field and Method Blanks

A field blank is a volume of contaminant-free water run through actual monitoring equipment and otherwise treated exactly as an urban runoff sample. The field blank is used to evaluate the sampling, container, and shipping systems for the presence of priority pollutant contaminants or other interfering substances. A method blank also consists of priority-pollutant-free water treated in the same manner as a runoff sample. Method blanks, however, are introduced in the laboratory and are used to evaluate reagents, laboratory methodology, and other aspects of the laboratory environment for the presence of contamination or measurement method interferences.

Results from field and method blanks were compared to sample results. Table 2 summarizes the use of blank sample results in the evaluation of NURP data. If a pollutant was not detected in the blanks the sample result was accepted (whether or not the pollutant was detected in the sample). If a pollutant was detected in the blank but not the sample, the sample result of "not detected" was also accepted. In some cases the pollutant was detected in both the blank and sample. If the blank value was equal to or greater than the sample value, the sample value was rejected. If the sample value was an order of magnitude greater than the blank value, the sample was accepted without adjustment for the blank value. In cases where the sample value exceeded the blank, but by less than an order of magnitude, it was difficult to establish the exact sample value with a high degree of confidence, given the proximity of both values to each other and to the method detection limit. In this situation, sample values were rejected.

TABLE 2
QC DECISION MATRIX FOR BLANK SAMPLE RESULTS

Blank Sample(B) Results for a Given Pollutant	Environmental Sample(E)	Additional Conditions	Action Taken on Data Point
Not Detected	Not Detected or Detected		Accept
Detected	Not Detected		Accept
Detected	Detected	$E \leq B$	Reject
Detected	Detected	$B < E < 10B$	Reject
Detected	Detected	$E \geq 10B$	Accept[a]

[a] Data point accepted without correction for blank value.

Of the 17 cities reporting results, approximately one third did not submit any field or method blank data. The remaining cities all submitted at least one field or method blank. Some of the data received from laboratories which did not report any blank results may have already been corrected for method blanks by the laboratories before reporting results to the cities. At least one such case is known to have occurred.

Replicate Samples

A replicate sample consists of an individual well-mixed sample which is divided into two or more separately analyzed aliquots. This is done to determine the precision with which the analytical method can measure identical samples. Results were acceptable if the difference between the two replicates was less than their average. Replicate sample results were submitted for about 30 percent of the total data base. This information was most complete for the inorganic pollutants.

In recording the data, the results of two acceptable replicate samples were averaged and given as the sample result. If one value was above the detection limit and the other not detected, only the detected value was given. In either case, the procedure used is noted by the appropriate STORET remark code (i.e., A = value reported is the mean of two or more determinations; G = value reported is the maximum of two or more determinations).

Performance Evaluation Samples

The performance evaluation (PE) samples are solutions containing known quantities of priority pollutants. PE samples were prepared by the Environmental Monitoring and Support Laboratory (EMSL) in Cincinnati, Ohio, and sent to each laboratory analyzing priority pollutants, to determine how well each laboratory's analytical methodology could duplicate a known result. The laboratories analyzed the PE samples as unknowns and reported back quantitative results for pollutants which they detected; the results were examined by EMSL and evaluated as acceptable, unacceptably high, or unacceptably low.

Table 3 summarizes the use of PE results. If the PE results for a pollutant were acceptable, then the sample result was accepted. If the PE results were unacceptably high, and the sample result reported as "Not Detected" (ND), then the sample was accepted as ND, since any lower value would still be ND. If the PE was high and the sample value was other than ND, the sample value was rejected.

If the PE for a pollutant was unacceptably low and the sample reported as ND, then the sample value was rejected. If the PE was low and the pollutant was detected, the sample value is recorded with the STORET remark code "L," for "actual value is known to be greater than value given."

Compounds not contained in the actual PE samples could be evaluated in certain limited cases by using the PE results for other similar compounds in the same pollutant class.

Some cities had different laboratories analyze their samples for inorganic and organic pollutants. Two laboratories which performed inorganic analyses only, and which did most of the inorganics analysis, are under contract to the Effluent Guidelines Division and were evaluated based on replicate sample results but not PE samples. The results of these replicate sample analyses were acceptable.

TABLE 3
QC DECISION MATRIX FOR PERFORMANCE EVALUATION SAMPLE RESULTS

Performance Evaluation[a]	Environmental Sample	Action Taken on Data Point
Acceptable	Not Detected or Detected	Accept
Unacceptably High	Not Detected (ND)	Accept
	Detected	Reject
Unacceptably Low	Not Detected	Reject
	Detected	Report with qualification[b]

[a] EMSL evaluation of sample results for a given pollutant. If a pollutant was not included in the PE sample, results for similar members of the pollutant class could be used for evaluation.

[b] Value reported and qualified with remark code "L," indicating "actual value is known to be greater than value given."

Surrogate Compounds

Surrogates are compounds which are chemically similar to priority pollutants, but not likely to be found in environmental samples. Known concentrations of surrogates are added to actual samples prior to analysis, to provide quality control by monitoring for unusual matrix effects, gross sampling errors, or other problems. Identical surrogates were provided to each laboratory by EMSL. However, many laboratories used surrogates from other EPA projects or other sources, either because more material was needed than originally anticipated, or because the laboratories were more familiar with their current surrogates. Reporting of surrogates results was incomplete, but results were used whenever possible.

Spiked Samples

Spiked samples are environmental samples to which known concentrations of priority pollutants have been added. The spiked samples are then processed as any other sample. Percent recovery results for the added materials are used to determine if complete recovery is being achieved by the measurement method. Results were considered acceptable if recoveries fell between 50 and 150 percent.

Incomplete information is available on spiked sample results, but, as for surrogates, results were used whenever possible. As mentioned, it is suspected that some laboratories which did not report this information may in fact have run the tests and used the results to correct their analytical data before reporting them to the NURP city.

Matrix Effects

Evaluation of the results of spiked and surrogate samples permits conclusions on the ability of the laboratory analytical system to accurately measure priority pollutants in a sample, given various effects and interactions possible within the pollutant-containing water matrix. Incomplete information on spiked and surrogate samples precludes an evaluation of matrix effects for the NURP priority pollutant data base.

SPECIAL CASES

In a memorandum dated May 14, 1980, EMSL noted that EPA Method 625 is not appropriate for the measurement of hexachlorocyclopentadiene, dimethyl nitrosamine, diphenyl nitrosamine, benzidine, or 1,2-diphenyl hydrazine (Appendix C). Inasmuch as all laboratories appear to have employed Method 625 for these determinations, the NURP results for the five compounds cannot be used.

Acrolein and acrylonitrile also represent special cases. While neither has been reported in runoff samples, both are highly unstable and should be analyzed within three days of sample collection, according to recommended EPA procedures. Such time constraints were impractical in the context of the NURP program. Moreover, standard analytical methods will not detect these pollutants except at relatively high concentrations. Thus, the NURP results for acrolein and acrylonitrile cannot be considered reliable evidence of the absence of these substances in runoff.

The pollutants dichlorodifluoromethane, trichlorofluoromethane, and bis(chloromethyl) ether have been removed from the original list of priority pollutants (44FR 18279 [1979] and 46FR 10723 [1981]). As these three compounds were included in laboratory reports, they have been retained in the NURP data base. However, considering the lability of bis(chloromethyl) ether in water (half-life: 30 seconds) it could not be expected in any of the samples. Dioxin, which was excluded from NURP, also represents a special case. The laboratories did scan their chromatograms for dioxin, although in no case was it detected.

FINDINGS OF THE QC EVALUATION

This subsection summarizes the findings of the QC evaluation for all 127 priority pollutants (asbestos and dioxin excluded). The data set was reviewed for completeness and evaluated according to the tests described previously. The data base contains 121 runoff samples for a potential maximum of 15,367 (121 x 127) data points.

Analytical Results Not Performed

A number of samples were not analyzed for one or more pollutants, either because the appropriate sample was not taken, the analysis was not performed, or, in one case, because of a broken sample bottle. This resulted in the loss of 1,361 possible observations from the data base.

Transcription or Labelling Error

One set of inorganic sample results was highly unusual in that the blank results which were reported appeared to be the actual sample results, and vice versa. This is possibly the result of a labelling or transcription error; however, investigation by the city failed to uncover an explanation for the results. The eight data points involved were rejected.

Blank Samples

QC review of the field and method blanks resulted in the rejection of 352 observations. Of these, about half related to the five organic compounds dichloromethane, benzene, toluene, di-n-butyl phthalate, and bis(2-ethylhexyl) phthalate.

Replicate Samples

All unacceptable replicate sample results are from samples which were withdrawn due to multiple QC problems. No data points were withdrawn solely on the basis of replicate sample results.

Performance Evaluation

Performance evaluation (PE) results from the laboratories are summarized in Table 4. If the PE was unacceptably low and a sample reported as ND, the data point was

TABLE 4. SUMMARY OF PERFORMANCE EVALUATION RESULTS[a]

Pollutant	Laboratory[b]							
	A	B	C	D	E	F	G	H
I. PESTICIDES								
5. γ-Hexachlorocyclohexane (γ-BHC) (Lindane)	H[c]		H	H	H			L
7. Chlordane	L[d]		H	H	L	L	L	L
8. DDD	H		H	H	H			L
9. DDE	H		L	H	H			L
10. DDT	H		H	H	H			L
11. Dieldrin			H					
12. α-Endosulfan			L	L	L			L
15. Endrin	H		H	H	H			L
17. Heptachlor	H		H	H	H			L
II. METALS AND INORGANICS								
22. Antimony								H
23. Arsenic					L			H
25. Beryllium								H
26. Cadmium					L			H
27. Chromium	H				L			H
28. Copper					L		L	
29. Cyanides	H	L						
30. Lead	H							H
31. Mercury					H			
32. Nickel		H		H	L			H
33. Selenium		H			L			
34. Silver								
35. Thallium								
36. Zinc					H			L
IV. HALOGENATED ALIPHATICS								
47. Methane, dichloro- (methylene chloride)	L							
51. Methane, trichloro- (chloroform)							H	L
52. Methane, tetrachloro- (carbon tet.)								
55. Ethane, chloro-			L				H	
58. Ethane, 1,1,1-trichloro-			H					
60. Ethane, 1,1,2,2-tetrachloro-				H				
63. Ethene, 1,1-dichloro-				L			H	L
64. Ethene, 1,2-*trans*-dichloro-				H				
66. Ethene, tetrachloro-							H	
67. Propane, 1,2-dichloro-								

(Continued)

TABLE 4. (Continued)

Pollutant	Laboratory[b]							
	A	B	C	D	E	F	G	H
VI. MONOCYCLIC AROMATICS (EXCLUDING PHENOLS, CRESOLS, PHTHALATES)								
78. Benzene							H	L
79. Benzene, chloro-								
87. Toluene							H	
VII. PHENOLS AND CRESOLS								
91. Phenol, 2-chloro-								
92. Phenol, 2,4-dichloro-						H		
93. Phenol, 2,4,6-trichloro-								
94. Phenol, pentachloro-								
95. Phenol, 2-nitro-				H				
97. Phenol, 2,4-dinitro-				H				
98. Phenol, 2,4-dimethyl-					L	L		
VIII. PHTHALATE ESTERS								
103. Phthalate, di-n-butyl					H			
105. Phthalate, bis(2-ethylhexyl)						H		
IX. POLYCYCLIC AROMATIC HYDROCARBONS								
107. Acenaphthene								
109. Anthracene	H							H
118. Fluorene								
121. Phenanthrene				H				
X. NITROSAMINES AND OTHER NITROGEN-CONTAINING COMPOUNDS								
126. Benzidine	L		L	H	L	L	L	
127. Benzidine, 3,3'-dichloro-			L		L	L		H

[a] A blank space in the table indicates an acceptable result on the performance evaluation. Table includes those priority pollutants present or reported to be present in the performance evaluation samples.

[b] The identity of the individual laboratories is intentionally omitted. Another laboratory reported results on a different PE sample which is not included in this summary, although the results were used in the QC evaluation.

[c] H indicates an unacceptably high result on the performance evaluation.

[d] L indicates an unacceptably low result on the performance evaluation.

rejected, resulting in the withdrawal of 328 observations. Criteria applied when the PE was high led to the rejection of an additional 110 data points. The most significant problems with PEs were in the pesticide group, particularly for chlordane, DDE, and α-endosulfan.

Surrogate Samples

No data points were rejected on the basis of surrogate sample results.

Spike Recoveries

Some 71 observations were rejected on the basis of an unacceptably low (<50%) or high (>150%) spike recovery result.

Holding Time Exceedances

Samples held in excess of allowable holding times resulted in the rejection of 361 data points. This includes all of the sample results for acrolein and acrylonitrile, two sets of inorganics results, and four sets of volatiles.

Inappropriate Detection Methods

Test results for five pollutants--hexachlorocyclopentadiene, dimethyl nitrosamine, diphenyl nitrosamine, benzidine, and 1,2-diphenyl hydrazine--were completely withdrawn because EPA has determined that Standard Method 625 is inappropriate for their analyses. This resulted in the loss of 552 observations.

Results Withheld by City

One city which performed some of its own quality control rejected the results from eight inorganic samples, or 117 observations, before releasing them to EPA.

Summary

The QC evaluation of 14,006 possible observations of pollutant concentrations for 127 priority pollutants in 121 samples resulted in the withdrawal of 1,899 observations from the data base. This represents 13.6 percent of the total observations from the 17 reporting cities. The largest number of withdrawals was due to inappropriate detection methods and unacceptable results on the performance evaluation, which together accounted for just over half of the withdrawn values. Table 5 summarizes the number of samples withdrawn for each category of QC violation.

TABLE 5

SUMMARY OF QC EVALUATION OF NURP PRIORITY POLLUTANT DATA BASE

Potential Data Base: 121 samples x 129 pollutants	15,609
Asbestos and dioxin excluded	242
Other analyses not performed	1,361
Total possible valid data points	14,006

Reason for withdrawl	Number of observations withdrawn	
Suspected errors in transcription	8	
Unacceptable blank values or suspected contamination	352	
Unacceptable low performance evaluation	328	
Unacceptable high performance evaluation	110	
Unacceptable spike recoveries	71	
Holding time exceedances	361	
Inappropriate detection methods	552	
Withdrawn by NURP city	117	
Total QC withdrawls	1,899	
Remaining acceptable observations		12,107

DISCUSSION OF QUALITY CONTROL EVALUATION FINDINGS

Certain quality control problems affected all members of a pollutant group. The inorganic pollutants suffered the most diverse quality control problems, including transcription errors, high blank values, holding time violations, an some PE problems. Nonetheless, the data base is of sufficient size to permit preliminary conclusions to be drawn regarding their significance in runoff. While the number of inorganics observations withdrawn was high, this is a function of the large number of detections for this group, and an implicit bias in our quality control methods which make it easier to reject a detected observation than a not detected one.

Systematic problems were noted for the pesticide group at several of the laboratories. Among the pesticides, problems were most significant for chlordane and α-endosulfan, for which 55 and 62 percent of the possible observations had to be withdrawn due to PE problems. While pesticides are clearly present in runoff, the rejection of so many observations indicates that the frequencies of detection calculated in the NURP program should be accepted with some caution.

Cases of unacceptable blanks and suspected contamination were also significant, perticularly for dichloromethane (methylene chloride), benzene, toluene, di-n-butyl phthalate, and bis(2-ethylhexyl) phthalate. Benzene and toluene are found in petroleum products and might reasonably be expected in urban runoff, although both are also common laboratory chemicals and potential contaminants. Methylene chloride is a common laboratory cleaning agent and a likely contaminant. In the absence of further correlating information, the results for these three compounds cannot reliably be accepted at this time. The two phthalates present a slightly different situation. Phthalates appear to be ubiquitously distributed in the environment to the extent that they often appear as contaminants. The NURP results should be interpreted as confirmation of the presence of these compounds in urban runoff, although their quantitation remains highly problematic.

Several implicit and explicit biases are known to be present in this QC evaluation, however, it was decided to accept many of these biases in an attempt to retain as much of the original data base as possible. First, the extent to which QC evaluation was possible depended on the amount of information submitted by the laboratories and cities. Because data for which there was little QC information were reported as is, laboratories which were more thorough in their reporting might end up with more observations withdrawn. This could introduce a bias into the remaining data base. However, the extent of rejected data should in no way whatever be construed as an indication of the quality of an individual laboratory.

A second factor is the possibility that some cities and laboratories performed their own QC procedures on the data before reporting them to EPA. This is known to have occurred in at least one instance, and may have occurred elsewhere. Because different criteria may have been applied in these instances, such QC evaluations can result in the inclusion or exclusion of data based on inconsistent criteria.

A third factor is the reporting formats and variations in limits of detection of different laboratories. Laboratories varied in the limits of detection reported for different pollutants. Even when the method was known to be the standard EPA methodology, the detection limits may or may not have equaled the limits listed in the Federal Register. Another aspect of this problem is the interpretation of what is "detectable" versus what is "quantifiable." There were clear differences among the laboratories in the extent to which they were willing to report apparent detections below the nominal detection limit. Observations of "present" which were reported by the laboratories but not quantified, or observations which were identified as uncertain, are remarked with the quality control code "M".

Another systemic problem involved the Performance Evaluations. The effects of the PEs were by and large the withdrawal of observations for those specific pollutants contained in the PE sample itself. It is possible that had more pollutants been included in the original PE sample, correspondingly more observations would have had to be withdrawn from the NURP data base. Thus, while the PEs served to estimate the accuracy of individual laboratories for pollutants included in the PE sample, it does not necessarily follow that the accuracy of the laboratory in analyzing other pollutants can be estimated, particularly because with such low concentrations the tendency of many laboratories is to underestimate concentrations.

Section 4. Findings

SECTION 4

FINDINGS

A pollutant-by-pollutant summary of the NURP findings, including the cities where detected, the frequency of detection, and the range of detected concentrations can be found in Table 6. A useful conceptual organization for reviewing the NURP findings is based on the diagram presented in Figure 2. This categorizes the pollutants into those detected in NURP runoff samples, pollutants not detected, pollutants for which the results are not valid, and pollutants not included in the NURP program. Each of these groups is discussed in turn.

POLLUTANTS DETECTED IN RUNOFF

Seventy-seven priority pollutants were detected in the NURP urban runoff samples. This group includes 14 inorganic and 63 organic pollutants (Table 6).

Inorganic Pollutants - As a group, the toxic metals are by far the most prevalent priority pollutant constituents of urban runoff. All 14 inorganics (13 metals plus cyanides) were detected, and all but three at frequencies of detection greater than 10 percent. Most often detected among the metals were copper, lead, and zinc, all of which were found in at least 91 percent of the samples. Other frequently detected inorganics included arsenic, chromium, cadmium, nickel, and cyanides (Table 7). Concentrations of copper, lead, and zinc were also among the highest for any pollutant, and reached a maximum of 100, 460, and 2,400 mg/l, respectively. To give a better indication of the central tendency of the results, geometric mean values were calculated for the more frequently detected pollutants, as described in Section 2. The highest mean values were for zinc at approximately 100 μg/l (Table 8). Twelve of the 13 toxic metals (antimony excluded) were also sampled in the special metals project in order to determine the relationships among dissolved, total, and total recoverable concentrations. The discussion and results of this separate effort are presented in Section 6.

A comparison of individual sample concentrations undiluted by stream flow with EPA water quality criteria and drinking water standards reveals numerous exceedances of

TABLE 6

SUMMARY OF ANALYTICAL CHEMISTRY FINDINGS FROM NURP PRIORITY POLLUTANT SAMPLES[a]
(includes information received through 9/30/83)

Pollutant	Cities where detected[b]	Frequency of detection (%)[c]	Range of detected concentrations (µg/l)[d]
I. PESTICIDES			
1. Acrolein	Holding times exceeded		
2. Aldrin	4, 7, 26	6	0.002T-0.1M
3. α-Hexachlorocyclohexane (α-BHC) (Alpha)	7, 8, 22, 26	20	0.0027-0.1M
4. β-Hexachlorocyclohexane (β-BHC) (Beta)	7, 8	5	0.018-0.1M
5. γ-Hexachlorocyclohexane (γ-BHC) (Gamma) (Lindane)	7, 8, 22, 26	15	0.007-0.1M
6. δ-Hexachlorocyclohexane (δ-BHC) (Delta)	7, 26	6	0.004-0.1M
7. Chlordane	2, 8, 21, 26	17	0.01L-10
8. DDD	Not detected		
9. DDE	26	6	0.007-0.027
10. DDT	7	1	0.1M
11. Dieldrin	26, 27	6	0.007-0.1
12. α-Endosulfan (Alpha)	7, 26, 27	19	0.008-0.2
13. β-Endosulfan (Beta)	Not detected		
14. Endosulfan sulfate	Not detected		
15. Endrin	Not detected		
16. Endrin aldehyde	Not detected		
17. Heptachlor	7, 8, 27	6	0.01-0.1M
18. Heptachlor epoxide	7, 26	2	0.003T-0.1M
19. Isophorone	7	3	10M
20. TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin)	Not included in NURP program		
21. Toxaphene	Not detected		
II. METALS AND INORGANICS			
22. Antimony	7, 24, 26	13	2.6-23A
23. Arsenic	2,3,7,12,19,20,21,22,26,27	52	1-50.5
24. Asbestos	Not included in NURP program		
25. Beryllium	7, 12, 20, 21	12	1-49
26. Cadmium	1,2,3,7,12,20,21,27	48	0.1M-14
27. Chromium	1,2,7,8,12,17,19,20,21,22,26,27,28	58	1-190
28. Copper	1,2,3,4,7,8,12,17,19,20,21,22,23,26,27,28	91	1L-100
29. Cyanides	4,8,19,22,26,27	23	2-300
30. Lead	1,2,3,4,7,8,12,17,19,20,21,22,26,28	94	6-460
31. Mercury	7,20,28	9	0.6-1.2
32. Nickel	2,3,7,12,20,21,26,27	43	1-182
33. Selenium	7,19,23	11	2-77
34. Silver	3,17,27	7	0.2M-0.8
35. Thallium	7	6	1-14
36. Zinc	1,2,3,7,12,17,19,20,21,22,23,27,28	94	10-2400

(continued)

TABLE 6. (Continued)

Pollutant	Cities where detected[b]	Frequency of detection (#)[c]	Range of detected concentrations (μg/l)[d]
III. PCBs AND RELATED COMPOUNDS			
37. PCB-1016 (Aroclor 1016)	Not detected		
38. PCB-1221 (Aroclor 1221)	Not detected		
39. PCB-1232 (Aroclor 1232)	Not detected		
40. PCB-1242 (Aroclor 1242)	Not detected		
41. PCB-1248 (Aroclor 1248)	Not detected		
42. PCB-1254 (Aroclor 1254)	Not detected		
43. PCB-1260 (Aroclor 1260)	2	1	0.03
44. 2-Chloronaphthalene	Not detected		
IV. HALOGENATED ALIPHATICS			
45. Methane, bromo- (methyl bromide)	Not detected		
46. Methane, chloro- (methyl chloride)	Not detected		
47. Methane, dichloro- (methylene chloride)	4, 17, 22	11	5-14.5A
48. Methane, chlorodibromo-	28	1	2
49. Methane, dichlorobromo-	28	1	2
50. Methane, tribromo- (bromoform)	28	1	1
51. Methane, trichloro- (chloroform)	4,17,20,22,23,27,28	9	0.2T-12L
52. Methane, tetrachloro- (carbon tetrachloride)	4, 28	3	1-2
53. Methane, trichlorofluoro-[e]	2,4,24,28	5	0.6T-27
54. Methane, dichlorodifluoro- (Freon-12)[e]	Not detected		
55. Ethane, chloro-	Not detected		
56. Ethane, 1,1-dichloro-	4,28	3	1.5A-3
57. Ethane, 1,2-dichloro-	28	1	4
58. Ethane, 1,1,1-trichloro-	4,2,7,22,24	6	1.6-10M
59. Ethane, 1,1,2-trichloro-	28	2	2-3
60. Ethane, 1,1,2,2-tetrachloro-	4	2	2G-3
61. Ethane, hexachloro-	Not detected		
62. Ethene, chloro- (vinyl chloride)	Not detected		
63. Ethene, 1,1-dichloro-	28	2	1.5-4
64. Ethene, 1,2-trans-dichloro-	20,28	4	1-3
65. Ethene, trichloro-	2,4,8,24,28	6	0.3T-12
66. Ethene, tetrachloro-	8,17,22,28	5	1M-43
67. Propane, 1,2-dichloro-	28	1	3
68. Propene, 1,3-dichloro-	28	2	1-2
69. Butadiene, hexachloro-	Not detected		
70. Cyclopentadiene, hexachloro-	Standard methods inappropriate		
V. ETHERS			
71. Ether, bis(chloromethyl)[e]	Not detected		
72. Ether, bis(2-chloroethyl)	Not detected		
73. Ether, bis(2-chloroisopropyl)	Not detected		
74. Ether, 2-chloroethyl vinyl	Not detected		
75. Ether, 4-bromophenyl phenyl	Not detected		
76. Ether, 4-chlorophenyl phenyl	Not detected		
77. Bis(2-chloroethoxy) methane	Not detected		

(continued)

TABLE 6. (Continued)

Pollutant	Cities where detected[b]	Frequency of detection (%)[c]	Range of detected concentrations (μg/l)[d]
VI. MONOCYCLIC AROMATICS (EXCLUDING PHENOLS, CRESOLS, PHTHALATES)			
78. Benzene	4,17,27	5	1-13
79. Benzene, chloro-	7,20,26,28	5	1G-10M
80. Benzene, 1,2-dichloro-	Not detected		
81. Benzene, 1,3-dichloro-	Not detected		
82. Benzene, 1,4-dichloro-	Not detected		
83. Benzene, 1,2,4-trichloro-	Not detected		
84. Benzene, hexachloro-	Not detected		
85. Benzene, ethyl-	4,8,17,20,26,28	6	1-2
86. Benzene, nitro-	Not detected		
87. Toluene	4,17	3	3-9
88. Toluene, 2,4-dinitro-	Not detected		
89. Toluene, 2,6-dinitro	Not detected		
VII. PHENOLS AND CRESOLS			
90. Phenol	4,7,26	14	1L-13T
91. Phenol, 2-chloro-	28	1	2
92. Phenol, 2,4-dichloro-	Not detected		
93. Phenol, 2,4,6-trichloro-	Not detected		
94. Phenol, pentachloro-	4,8,19,20,26,27,28	19	1T-115
95. Phenol, 2-nitro-	8	1	1M
96. Phenol, 4-nitro-	4,7,8,20,26,28	10	1T-37
97. Phenol, 2,4-dinitro-	Not detected		
98. Phenol, 2,4-dimethyl-	4,7,8,26	8	1T-10M
99. m-Cresol, p-chloro-	4	1	1.5A
100. o-Cresol, 4,6-dinitro-	Not detected		
VIII. PHTHALATE ESTERS			
101. Phthalate, dimethyl	8	1	1L
102. Phthalate, diethyl	3,4,17,20,21	6	1-10M
103. Phthalate, di-n-butyl	4,22,24	6	0.5T-11
104. Phthalate, di-n-octyl	8,20,26,27,28	6	0.4T-2G
105. Phthalate, bis(2-ethylhexyl)	4,12,19,22,21,26	22	4T-62
106. Phthalate, butyl benzyl	2,8,26	6	1-10M
IX. POLYCYCLIC AROMATIC HYDROCARBONS			
107. Acenaphthene	Not detected		
108. Acenaphthylene	Not detected		
109. Anthracene	2,17,20,21,26,28	7	1-10M
110. Benzo(a)anthracene	2,21,27	4	1-10M
111. Benzo(b)fluoranthene	26,27	5	1-5

TABLE 6. (Continued)

Pollutant	Cities where detected[b]	Frequency of detection (%)[c]	Range of detected concentrations (µg/l)[d]
112. Benzo(k)fluoranthene	2,21,27	3	4-14
113. Benzo(g,h,i)perylene	21	1	5
114. Benzo(a)pyrene	2,21,26,27	6	1-10M
115. Chrysene	2,7,17,21,26,27	10	0.6T-10M
116. Dibenzo(a,h)anthracene	21	1	1T
117. Fluoranthene	2,8,12,17,21,26,27,28	16	0.3T-21
118. Fluorene	28	1	1
119. Indeno(1,2,3-c,d)pyrene	21	1	4
120. Naphthalene	4,24,26,28	9	0.8T-2.3
121. Phenanthrene	2,8,17,20,21,26,27,28	12	0.3T-10M
122. Pyrene	2,3,8,12,17,21,26,27,28	15	0.3T-16
X. NITROSAMINES AND OTHER NITROGEN-CONTAINING COMPOUNDS			
123. Nitrosamine, dimethyl (DMN)	Standard methods inappropriate		
124. Nitrosamine, diphenyl	Standard methods inappropriate		
125. Nitrosamine, di-n-propyl	Not detected		
126. Benzidine	Standard methods inappropriate		
127. Benzidine, 3,3'-dichloro-	Not detected		
128. Hydrazine, 1,2-diphenyl-	Standard methods inappropriate		
129. Acrylonitrile	Holding times exceeded		

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[a] Based on 121 sample results received as of 9/30/83, adjusted for quality control review.

[b] Cities from which data are available:

1. Durham, NH
2. Lake Quinsigamond, MA
3. Mystic River, MA
4. Long Island, NY
7. Washington, DC
8. Baltimore, MD
12. Knoxville, TN
17. Glen Ellyn, IL
19. Austin, TX
20. Little Rock, AR
21. Kansas City, KS
22. Denver, CO
23. Salt Lake City, UT
24. Rapid City, SD
26. Fresno, CA
27. Bellevue, WA
28. Eugene, OR

Numbering of cities conforms to NURP convention.

[c] Percentages rounded to nearest whole number.

[d] Some reported concentrations are qualified by STORET quality control remark codes, to wit: A = Value reported is the mean of two or more determinations; G = Value reported is the maximum of two or more determinations; L = Actual value is known to be greater than value given; M = Presence of material verified but not quantified; T = Value reported is less than criteria of detection. One value in this column indicates one positive observation or that all observations were equal.

[e] No longer included as a priority pollutant.

FIGURE 2

CATEGORIZATION OF 129 PRIORITY POLLUTANTS

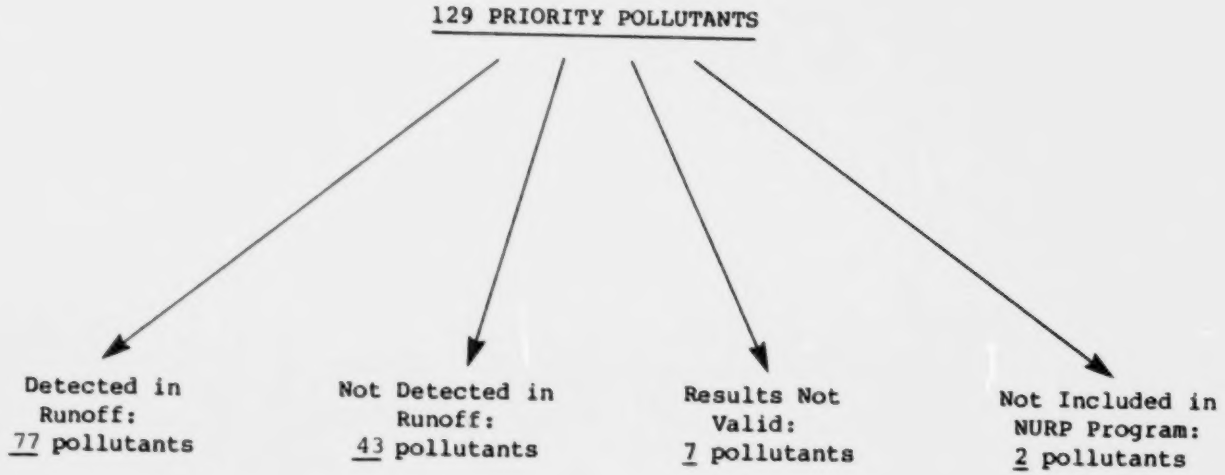
129 PRIORITY POLLUTANTS
Detected in Runoff: 77 pollutants
Not Detected in Runoff: 43 pollutants
Results Not Valid: 7 pollutants
Not Included in NURP Program: 2 pollutants

TABLE 7.

MOST FREQUENTLY DETECTED PRIORITY POLLUTANTS IN NURP URBAN RUNOFF SAMPLES[a]

Priority Pollutants Detected in 75% or More of the NURP Samples

Inorganics	Organics
30. Lead (94%)	None
36. Zinc (94%)	
28. Copper (91%)	

Priority Pollutants Detected in 50% to 74% of the NURP Samples

Inorganics	Organics
27. Chromium (58%)	None
23. Arsenic (52%)	

Priority Pollutants Detected in 20% to 49% of the NURP Samples

Inorganics	Organics
26. Cadmium (48%)	105. Bis(2-ethylhexyl) phthalate (22%)
32. Nickel (43%)	3. α-Hexachlorocyclohexane (20%)
29. Cyanides (23%)	

Priority Pollutants Detected in 10% to 19% of the NURP Samples

Inorganics	Organics
22. Antimony (13%)	12. α-Endosulfan (19%)
25. Beryllium (12%)	94. Pentachlorophenol (19%)
33. Selenium (11%)	7. Chlordane (17%)
	5. γ-Hexachlorocyclohexane (Lindane) (15%)
	122. Pyrene (15%)
	90. Phenol (14%)
	121. Phenanthrene (12%)
	47. Dichloromethane (methylene chloride) (11%)
	96. 4-Nitrophenol (10%)
	115. Chrysene (10%)
	117. Fluoranthene (16%)

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[a] Based on 121 sample results received as of 9/30/83, adjusted for quality control review. Does not include special metals samples.

TABLE 8.

RANGE OF GEOMETRIC MEANS FOR POLLUTANTS FOUND AT LEAST 20% OF THE TIME[a]

Pollutant	Geometric mean (µg/l)		Occurrence (%)
	Low	High	
3. α - Hexachlorocyclohexane	0.057	0.36	20
23. Arsenic	2.18	6.63	52
26. Cadmium	0.54	1.84	48
27. Chromium	3.49	9.18	58
28. Copper	15.8	19.5	91
29. Cyanide	2.78	17.09	23
30. Lead	70.8	81.7	94
32. Nickel	5.3	19.8	43
36. Zinc	89.7	103.9	94
105. Phthalate, bis(2-ethylhexyl)	1.84	10.44	22

[a] For explanation of method of calculation, see Section 2.

these levels, as shown in Table 9. Freshwater acute criteria were exceeded by copper concentrations in 47 percent of the samples, and by lead in 23 percent. Freshwater chronic exceedances were common for lead (94%), copper (82%), zinc (77%), and cadmium (48%). No organoleptic (taste and odor) criteria exceedances were observed. Regarding human toxicity, the most significant pollutants were lead and nickel, and for human carcinogenesis, arsenic and beryllium. Lead concentrations violated drinking water criteria 73 percent of the time.

Whenever an exceedance is noted above, it does not necessarily imply that an actual violation of criteria did or will take place in receiving waters. Rather, the enumeration of exceedances is used as a screening procedure, to make a preliminary identification of those pollutants whose presence in urban runoff requires highest priority for further evaluation. Exceedances of freshwater chronic criteria levels may not persist for a full 24-hour period, for example. However, many small urban streams probably carry only slightly diluted runoff following storms, and acute criteria or other exceedances may in fact be real in such circumstances.

Among the inorganics, then, the most frequently detected pollutants are also those which are found at the highest concentrations, which most frequently exceed water quality criteria, and which are the most well-distributed, geographically. One additional observation can be made concerning the samples from Washington, D.C. These samples accounted for many of the detections among the less frequently detected inorganics, including antimony, beryllium, mercury, selenium, and thallium. No sampling or analytical irregularities have been identified which explain this result.

Organic Pollutants

In general, the organic pollutants were detected less frequently and at lower concentrations than the inorganic pollutants. Sixty-three of a possible 106 organic pollutants were detected. The most commonly found organic was the plasticizer bis(2-ethylhexyl) phthalate (22%), followed by the pesticide α-hexachlorohexane (α-BHC) (20%). An additional 11 organic pollutants were reported with frequencies between 10 and 20 percent; 3 pesticides, 3 phenols, 4 polycyclic aromatics, and a single halogenated aliphatic (Table 7). Ranges of concentrations can be found in Table 6, and selected geometric mean values in Table 8.

TABLE 9.

SUMMARY OF WATER QUALITY CRITERIA EXCEEDANCES FOR POLLUTANTS DETECTED IN AT LEAST 10 PERCENT OF NURP SAMPLES: PERCENTAGE OF SAMPLES IN WHICH POLLUTANT CONCENTRATIONS EXCEED CRITERIA[a]

Pollutant	Frequency of Detection (%)	Detections/ Samples[b]	Criteria Exceedances (%)[c]						
			None	FA	FC	OL	HH	HC[d]	DW
I. PESTICIDES									
3. α-Hexachlorocyclohexane	20	21/106						8,18,20	
5. γ-Hexachlorocyclohexane (Lindane)	15	15/100			8			0,10,15	
7. Chlordane	17	7/42		2	17			17,17,17	
12. α-Endosulfan	19	9/49			10				
II. METALS AND INORGANICS									
22. Antimony	13	14/106	X						
23. Arsenic	52	45/87						52,52,52	1
25. Beryllium	12	11/94			6*			12,12,12	
26. Cadmium[e]	48	44/91		8	48		1		1
27. Chromium[e,f]	58	47/81			1*				1
28. Copper[e]	91	79/87		47	82				
29. Cyanides	23	16/71		3	22		4		
30. Lead[e]	94	75/80		23	94		73		73
32. Nickel[e]	43	39/91			5		21		
33. Selenium	11	10/88			5		10		10
36. Zinc[e]	94	88/94		14	77				
IV. HALOGENATED ALIPHATICS									
47. Methane, dichloro-	11	3/28						0,0,11	
VII. PHENOLS AND CRESOLS									
90. Phenol	14	13/91	X						
94. Phenol, pentachloro-	19	21/111		1*	11*	1			
96. Phenol, 4-nitro-	10	11/107	X						
VIII. PHTHALATE ESTERS									
105. Phthalate, bis(2-ethylhexyl)	22	15/69			22*				
IX. POLYCYCLIC AROMATIC HYDROCARBONS									
115. Chrysene	10	11/109						10,10,10	
117. Fluoranthene	16	17/109	X						
121. Phenanthrene	12	13/110						12,12,12	
122. Pyrene	15	16/110						15,15,15	

* Indicates FTA or FTC value substituted where FA or FC criterion not available (see below).

[a] Based on 121 sample results received as of 9/30/83, adjusted for quality control review.

[b] Number of times detected/number of acceptable samples.

[c]
FA = Freshwater ambient 24-hour instantaneous maximum criterion ("acute" criterion).
FC = Freshwater ambient 24-hour average criterion ("chronic" criterion).
FTA = Lowest reported freshwater acute toxic concentration. (Used only when FA is not available.)
FTC = Lowest reported freshwater chronic toxic concentration. (Used only when FC is not available.)
OL = Taste and odor (organoleptic) criterion.
HH = Non-carcinogenic human health criterion for ingestion of contaminated water and organisms.
HC = Protection of human health from carcinogenic effects for ingestion of contaminated water and organisms.
DW = Primary drinking water criterion.

[d] Entries in this column indicate exceedances of the human carcinogen value at the 10^{-5}, 10^{-6}, and 10^{-7} risk level, respectively. The numbers are cumulative, i.e., all 10^{-5} exceedances are included in 10^{-6} exceedances, and all 10^{-6} exceedances are included in 10^{-7} exceedances.

[e] Where hardness dependent, hardness of 100 mg/l $CaCO_3$ equivalent assumed.

[f] Different criteria are written for the trivalent and hexavalent forms of chromium. For purposes of this analysis, all chromium is assumed to be in the less toxic trivalent form.

Criteria exceedances were less frequently observed among the organics than the inorganics. One unusually high pentachlorophenol concentration of 115 μg/l resulted in the only exceedance of the organoleptic criteria (Table 9). This observation and one for chlordane exceeded the freshwater acute criteria. Freshwater chronic criteria exceedances were observed for pentachlorophenol, bis(2-ethylhexyl) phthalate, α-hexachlorocyclohexane (γ-BHC or Lindane), α-endosulfan and chlordane. All other organic exceedances were in the human carcinogen category, and were most serious for α-hexachlorocyclohexane (α-BHC), γ-BHC, chlordane, phenanthrene, pyrene, and chrysene.

An additional 50 organic pollutants were found in one to nine percent of the samples. These frequencies of detection are low and the pollutants noted in Table 10.

Among the PCB group, there was only a single detection of one PCB type among all the samples. Approximately two-thirds of the halogenated aliphatic compounds were detected. Among those cities reporting these compounds, the city of Eugene, Oregon, figured prominently. For example, eight pollutants from this group were found in Eugene only. None of the pollutants in the ethers group were detected.

Monocyclic aromatics were rarely detected in the samples. However, many reported detections of benzene and toluene, two commonly reported pollutants, had to be withdrawn due to contamination problems.

Of the 11 phenolics, four have not been reported in urban runoff, while three have been observed only once. The remaining four have been found fairly frequently but at low concentrations. Exceedances of criteria were noted only for pentachlorophenol.

All the phthalate esters were detected at least once in the NURP program, with bis(2-ethylhexyl) found most frequently. Several times the reported concentration exceeded the lowest observed freshwater acute toxic concentration for this pollutant. Given the significant blank contamination problems with the phthalates, however, these findings must be interpreted with caution.

Only two of the polycyclic aromatic hydrocarbons were not detected in at least one sample. Crysene, phenanthrene, pyrene and fluoranthene were each found at least 10 percent of the time. All the observed concentrations for the first three of these pollutants exceeded the criteria for the protection of human health from carcinogenic

TABLE 10

INFREQUENTLY DETECTED ORGANIC PRIORITY POLLUTANTS IN NURP URBAN RUNOFF SAMPLES[a]

Priority Pollutants Detected in 1% to 9% of the NURP Samples

51. Trichloromethane (9%)
120. Naphthalene (9%)
98. 2,4-Dimethyl phenol (8%)
109. Anthracene (7%)
2. Aldrin (6%)
6. δ-Hexachlorocyclohexane (6%)
9. DDE (6%)
11. Dieldrin (6%)
17. Heptachlor (6%)
58. 1,1,1-Trichloroethane (6%)
65. Trichloroethene (6%)
85. Ethylbenzene (6%)
102. Diethyl phthalate (6%)
103. Di-n-butyl phthalate (6%)
104. Di-n-octyl phthalate (6%)
106. Butyl benzyl phthalate (6%)*
114. Benzo(a)pyrene (6%)
4. β-Hexachlorocyclohexane (5%)
53. Trichlorofluoromethane (5%)[b]
66. Tetrachloroethene (5%)
78. Benzene (5%)
79. Chlorobenzene (5%)
111. Benzo(b)fluoranthene (5%)*
64. 1,2-*trans*-dichloroethene (4%)
110. Benzo(a)anthracene (4%)
19. Isophorone (3%)
52. Tetrachloromethane (carbon tetrachloride) (3%)
56. 1,1-Dichloroethane (3%)
87. Toluene (3%)
112. Benzo(k)fluoranthene (3%)
18. Heptachlor epoxide (2%)*
59. 1,1,2-Trichloroethane (2%)*
60. 1,1,2,2-Tetrachloroethane (2%)*
63. 1,1-Dichloroethene (2%)
68. 1,3-Dichloropropene (2%)*
113. Benzo(g,h,i)perylene (2%)
10. DDT (1%)*
43 PCB-1260 (1%)*
48. Chlorodibromomethane (1%)*
49. Dichlorobromomethane (1%)*
50. Tribromomethane (bromoform) (1%)*
57. 1,2-Dichloroethane (1%)*

(Continued)

TABLE 10. (Continued)

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67. 1,2-Dichloropropane (1%)*
91. 2-Chlorophenol (1%)*
95. 2-Nitrophenol (1%)*
99. p-Chloro-m-cresol (1%)*
101. Dimethyl phthalate (1%)*
116. Dibenzo(a,h)anthracene (1%)*
118. Fluorene (1%)*
119. Indeno(1,2,3-cd)pyrene (1%)*

Priority Pollutants Not Detected in NURP Samples

8. DDD
13. β-Endosulfan
14. Endosulfan sulfate
15. Endrin
16. Endrin aldehyde
21. Toxaphene
37. PCB-1016
38. PCB-1221
39. PCB-1232
40. PCB-1242
41. PCB-1248
42. PCB-1254
44. 2-Chloronaphthalene
45. Bromomethane (methyl bromide)
46. Chloromethane (methyl chloride)
54. Dichlorodifluoromethane (Freon-12)[b]
55. Chloroethane
61. Hexachloroethane
62. Chloroethene (vinyl chloride)
69. Hexachlorobutadiene
71. Bis(chloromethyl) ether[b]
72. Bis(chloroethyl) ether
73. Bis(chloroisopropyl) ether
74. 2-Chloroethyl vinyl ether
75. 4-Bromophenyl phenyl ether
76. 4-Chlorophenyl phenyl ether
77. Bis(2-chloroethoxy) methane
80. 1,2-Dichlorobenzene
81. 1,3-Dichlorobenzene
82. 1,4-Dichlorobenzene
83. 1,2,4-Trichlorobenzene
84. Hexachlorobenzene
86. Nitrobenzene
88. 2,4-Dinitrotoluene
89. 2,6-Dinitrotoluene
92. 2,4-Dichlorophenol
93. 2,4,6-Trichlorophenol

(Continued)

TABLE 10. (Continued)

97. 2,4-Dinitrophenol
100. 4,6-Dinitro-o-cresol
107. Acenaphthene
108. Acenaphthylene
125. Di-n-propyl nitrosamine
127. 3,3'-Dichlorobenzidine

Priority Pollutants Not Analyzed for or Withdrawn for Methodological Reasons or Holding Time Violations

1. Acrolein
20. TCDD (Dioxin)
24. Asbestos
70. Hexachlorocyclopentadiene
123. Dimethyl nitrosamine (DMN)
124. Diphenyl nitrosamine
126. Benzidine
128. 1,2-Diphenyl hydrazine
129. Acrylonitrile

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*Detected in only one or two samples.

[a] Based on 121 sample results received as of 9/30/83, adjusted for quality control review.

[b] No longer on the priority pollutant list.

effects (there are no such criteria for fluoranthene). Results for the polycyclic aromatics were generally free from quality control problems.

There were no detections of nitrosamines or other nitrogen-containing compounds. Due to methodological and holding time problems, however, results for only two compounds can be used. Moreover, for one of these compounds, 3,3-dichlorobenzidine, performance evaluation results were unacceptable in several cases.

POLLUTANTS NOT DETECTED IN RUNOFF

Some 43 priority pollutants were not detected in any acceptable runoff samples (Table 10). All of these pollutants are organics. This group of substances should be considered to pose a minimal threat to the quality of surface waters from runoff contamination.

While the priority pollutants which were not detected are of less immediate concern than those pollutants found often, they cannot safely be eliminated from all future consideration. Many of these pollutants have associated water quality criteria which are below the limits of detection of routine analytical methods. Some of these substances may in fact have been present in the NURP samples. Four priority pollutants not detected in runoff were found in street dust sweepings from Bellevue, Washington, suggesting that further urban runoff samplings can be expected to detect more priority pollutants. More sensitive analytical methodologies must be used and dilution effects considered before it can be said with assurance that these pollutants are not found in urban stormwater runoff at levels which pose a threat to human health or aquatic life.

DDD, chloromethane, 1,2-dichlorobenzene, and 2,4-dichlorophenol were all detected in runoff samples at least once, but these observations had to be withdrawn for quality control reasons. Therefore, among the not detected pollutants, these four can be considered to have a slightly elevated possibility of actually being present in the runoff samples.

RESULTS NOT VALID

The NURP results for seven priority pollutants cannot be considered valid. As noted in Section 3 and Appendix C, recent EPA investigation has revealed that standard methods are not appropriate for the measurement of hexachlorocyclopentadiene, dimethyl nitrosamine, diphenyl nitrosamine, benzidine, and 1,2-diphenylhydrazine, and that permissible holding times are very short for acrolein and acrylonitrile.

OTHER POLLUTANTS

A number of non-priority pollutants were reported by the laboratories analyzing the Denver and Kansas City runoff samples (Table 11). For example, the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) was found at a concentration of 180 μg/l, a level which exceeds its Red Book drinking water standard of 100 μg/l (EPA, 1977). (Note: The value 100 μg/l is apparently an error. The true value should be 10 μg/l according to the American Fisheries Society, 1979.) These results indicate that some toxic compounds which are not priority pollutants may be found in runoff, and that such compounds may require further investigation and control at some time in the future.

TABLE 11.

NON-PRIORITY POLLUTANTS REPORTED IN NURP URBAN RUNOFF SAMPLES

Pollutant	Estimated concentration ($\mu g/l$)	Number of times detected/Number of samples
6-Methoxy-N,N'-bis(1-methylethyl)-1,3,5-triazine-2,4-dione	64	1/7
4-Propoxyphenol	8	1/7
Methylheptanol	12	1/7
3-Methyl-2-cyclohexen-1-one	6-9	4/7
1-(2-Butoxyethoxy)ethanol	5-23	2/7
2,2,4-Trimethyl-1,3-pentanediol	17	1/7
Tributylphosphate	6	1/7
9,10-Anthracenedione or 9,10-Phenanthrenedione	20-29	2/7
2,4-Dichlorophenoxyacetic acid (2,4-D)	180	1/7
(1,1'-biphenyl)-carboxaldehyde	17	1/7
Unidentified substituted alkyl hydrocarbon	5-37	3/7
Unidentified substituted alkyl hydrocarbon	12-390	2/7
Unidentified substituted alkyl hydrocarbon oil	10-500	2/7
Unidentified substituted polycyclic aromatic	22	1/7
2,/2-(2-Butoxyethoxy)ethoxy/ethanol	8	1/7
1,2-Benzene dicarboxylic acid dibutyl ester		
Octadecane		
Elcosane		
Pentacosane		
1-pentanol, 2-ethyl-4-methyl		
2-pentanone, 4-hydroxy-4-methyl		
Methylbenzene		
Cyclopentanol, 2-methyl		
1,1-Bicyclohexyl		
1,3-Dimethyl benzene		
1,3,4-Trimethyl benzene		
9,10-Anthracenedione		
Hexadecane		
1,3,5-Hydroxydecanoic acid		
2-Chloro-6-methyl phenol		
Tricosane		
Undecane		
2-Methylundecane		
Pentatriacentane		
4,6,8-Trimethyl-1-nonene		
4,4-Dimethyl-2-pentene		
Pentadecanoic acid		
3,3-Dimethyl hexane		

SECTION 5

CONCLUSIONS

Section 4 identified the inorganic and organic priority pollutants which were detected most frequently in urban runoff and which were found at concentrations which exceeded applicable water quality criteria and standards. The 24 pollutants (11 inorganics and 13 organics) detected in at least 10 percent of the urban runoff samples have been selected for further evaluation and discussion in this section, and their implications for the protection and maintenance of water quality are considered. Dichloromethane (methylene chloride) has been excluded from this discussion due to the widespread contamination problems experienced with this pollutant. A cutoff point of 10 percent was established in order to avoid drawing conclusions based on very few observations for a pollutant and to minimize the importance of unusual runoff conditions.

The priority pollutants found in 10 percent or more of the NURP samples, and their predominant sources, are shown in Table 12. In general, inorganic priority pollutants were found more frequently and at higher concentrations than the organic priority pollutants. The nine toxic metals also included in the special metals project were found less frequently in that program than in the priority pollutant project. This is most likely due to the higher detection limits employed in the special metals effort (see Section 6). Predominant sources of the priority pollutant metals in runoff are thought to be gasoline and other fossil fuel combustion, metal alloy corrosion, and other automobile-related activities. The predominant sources of the priority pollutant organics are believed to be pesticides, fossil fuel combustion, plastic products, automobile-related activities.

The reader is reminded that the sites which were selected for sampling in this project were predominantly residential and commercial. Industrial land use runoff, which may have different water quality characteristics, is not represented in these results.

TABLE 12.

PREDOMINANT SOURCES OF PRIORITY POLLUTANTS WHICH HAVE BEEN DETECTED IN AT LEAST 10 PERCENT OF URBAN RUNOFF SAMPLES

Pollutant	Predominant sources
	a. Fossil Fuel Combustion
115. Chrysene 117. Fluoranthene 121. Phenanthrene 122. Pyrene	Products of the incomplete combustion of fossil fuels, especially wood and coal burned in residential home heating units.
23. Arsenic 32. Nickel	Products of fossil fuel combustion.
	b. Gasoline Consumption
30. Lead	Component of gasoline
29. Cyanides	Products of gasoline combustion
	c. Metal Alloy Corrosion
26. Cadmium 27. Chromium	Metals released from the corrosion of alloys and plated surfaces and from electroplating wastes.
28. Copper	Metal released from the corrosion of copper plumbing and from electroplating wastes. Copper is also commonly used in algicides.
	d. Automobile Related Activities
29. Cyanides	Anti-caking ingredients in road salts.
36. Zinc	Component of automobile tires and a common ingredient in road salt.
	e. Pesticide Use
3. α-Hexachlorocyclohexane 5. γ-Hexachlorocyclohexane (Lindane) 7. Chlordane 12. α-Endosulfan	Compounds commonly used in soil treatment to eliminate nematodes and for other pesticide uses.

(continued)

TABLE 12. (Continued)

Pollutant	Predominant Sources
94. Pentachlorophenol	Primarily used to protect wood products from microbial and fungal decay. Telephone poles are commonly treated with pentachlorophenol, for example.
96. 4-Nitrophenol	Used in the manufacture of ethyl and methyl parathion.
	f. Exterior Paints and Stains
27. Chromium 30. Lead 36. Zinc 94. Pentachlorophenol	Components and pigments found in painting and staining products, however, use of several of these additives is being reduced or eliminated.
	g. Plastic Products
90. Phenol	Used as an intermediate in the production of phenolic resins for plasticizers and other products. Phenol is also used to produce pharmaceuticals, germicides, fungicides, dyes, and some industrial acids.
105. Bis(2-ethylhexyl) phthalate	A widely used plasticizer (component which makes plastic flexible). It finds its way into urban runoff because, through time, it "leaches" from numerous plastic products (such as garden hoses, floor tiles, plastic containers, and food packaging).
	h. Natural Erosion
22. Antimony 25. Beryllium 33. Selenium	Elements which occur naturally in rocks and soil.

POTENTIAL RISKS TO HUMAN HEALTH

A comparison of undiluted NURP priority pollutant concentrations with EPA's human health criteria for water revealed that the organic priority pollutants found most frequently pose little risk to humans at detected levels, except possibly for α-hexachlorocyclohexane (α-BHC) and chlordane. These pesticides and the three polycyclic aromatic hydrocarbons (PAHs), chrysene, phenanthrene, and pyrene, were found in 5 to 20 percent of the urban runoff samples at concentrations exceeding the EPA criteria for the protection of human health from carcinogenesis at the 10^{-5} risk level. Criteria established for chrysene, phenanthrene, and pyrene are based on these PAHs being as potent as benzo(a)pyrene. There is no evidence to date of the mutagenic or carcinogenic activity by these three compounds from animal studies. At the 10^{-7} risk level, γ-hexachlorocyclohexane (lindane) also exceeded the carcinogenic criteria in at least 10 percent of the samples. Pentachlorophenol (PCP) exceeded the organoleptic (taste and odor) criterion in one sample, although it was found in 21 samples. PCP does not appear to be a carcinogen, but tests with rats have shown it to be teratogenic and fetotoxic. No organic pollutants in the 10 percent group were found at concentrations greater than the noncarcinogenic human toxicity criteria.

PCP has a short lifetime in water, because photolysis degrades it in streams within approximately one week. However, where conditions such as turbidity limit photolysis, degradation may take as long as several months. PCP also sorbs to sediments where it can persist for months and eventually recontaminate the water column, which can be a problem in streams that are attempting to recover from intermittent or continuous discharges. Chrysene, phenanthrene, and pyrene can also be adsorbed to sediments where they can persist and recontaminate the water column. The effect of remobilization of these pollutants from sediments must be further evaluated before a conclusion regarding potential risk to human health can be fully stated.

The predominant pathway for human exposure to the organics associated with gasoline is through ingested food and inhalation. Contaminated surface water should therefore pose little risk at the levels measured in NURP samples. The plasticizers and pesticides should also pose a minimal threat to humans as contaminated surface water is an insignificant exposure pathway for these chemicals. The plasticizer values in urban runoff are orders of magnitude below toxic levels (Appendix B). However, bis(2-ethylhexyl) phthalate has been shown to accumulate in aquatic life and sediments. The effects of human exposure to bis(2-ethyl- hexyl) phthalate at measured concentrations due to these pathways are currently unknown.

Additional dilution during storm events will likely reduce the concentrations of these pollutants from the levels measured in runoff. This, in addition to the known fates and pathways of the organic priority pollutants, suggests a minimal risk to humans due to urban runoff-borne organic pollutants.

Some of the priority pollutant metals found in urban runoff from predominantly residential and commercial sites could represent a potential risk to human health. Exceedances of the non-carcinogenic human health, drinking water, and human carcinogenic criteria were observed. Detected lead concentrations in undiluted runoff ranged from 6 to 460 µg/l and exceeded the drinking water standard and human health criterion of 50 µg/l (total lead) in 73 percent of the samples. Selenium concentrations in undiluted runoff from 2 to 77 µg/l surpassed the drinking water standard and human health criterion of 10 µg/l (total selenium) in 10 percent of the samples. Although dilution in receiving streams and subsequent treatment in drinking water treatment facilities would probably reduce these observed concentrations, drinking water standard violations are still possible under worst case conditions. Such conditions would include cases where: (1) the runoff generated during a storm event represented a large portion of the total receiving water flow, resulting in a dilution of less than 1 to 10; (2) the preliminary sampling results are representative of lead and selenium concentrations above drinking water supply intakes; and (3) lead and selenium removal by public drinking water treatment facilities is minimal. Specific risks to drinking water supplies could be evaluated by sampling during storm events.

Nickel concentrations in undiluted runoff were found to exceed the human health criterion of 13.4 µg/l (total nickel) in 21 percent of the samples with detected total nickel concentrations ranging from 1 to 182 µg/l. Violations are expected to be less than the 21 percent figure after dilution by receiving streams. Moreover, nickel is not considered a significant human health problem in water because it is poorly absorbed by the body when ingested. Inhalation of nickel, especially nickel carbonyl, poses the greatest risk to human health. However, nickel compounds are suspected of acting synergistically with some carcinogens to increase mutagenic effects (Sunderman, 1981).

Arsenic concentrations in undiluted runoff frequently exceeded the EPA human carcinogenic criterion (10^{-5} risk level) of 0.022 µg/l. There is, however, presently a debate on the carcinogenic potency of arsenic, and this precludes a meaningful assessment of the risk to humans at this time. Only one arsenic concentration in the undiluted runoff equalled the 50 µg/l EPA drinking water standard. Beryllium concentrations exceeded the carcinogenic criteria in 12 percent of the samples, that is, in all observations for which this element was detected. The primary exposure pathway for humans, however, is through airborne beryllium.

POTENTIAL RISKS TO AQUATIC LIFE

Since most storms last between two and 16 hours, the most meaningful measure of potential aquatic life effects is a comparison of pollutant concentrations with acute water quality criteria and toxicity values. If pollutant levels exceed these values before dilution, then aquatic species are likely to be impacted in the mixing zone.

Pentachlorophenol and chlordane were the only organic priority pollutant to exceed freshwater acute aquatic life criteria. This occurred in only one sample for each pollutant, although pentachlorophenol, for example, was detected 21 times. Freshwater chronic aquatic life criteria levels were surpassed by reported concentrations of γ-hexachlorocyclohexane (lindane), chlordane, α-endosulfan, pentachlorophenol, and bis(2-ethylhexyl) phthalate.

Four priority pollutant metals--cadmium, copper, lead, and zinc--exceeded freshwater acute aquatic life criteria in 8 to 47 percent of the samples. The highest detected values for these pollutants were two to eight times higher than their related criteria. Consequently, these pollutants could cause harm to aquatic life, depending upon receiving stream dilution. These results are similar to those found in the special metals project. Furthermore, in the special metals project 40 percent of the copper and zinc levels are found in the dissolved form which is generally the most toxic form of the metals.

These same four priority pollutant metals, plus cyanides, also exceeded the 24-hour freshwater chronic criterion (or the lowest reported toxic concentration) in at least 10 percent of the samples. The highest detected values for these pollutants ranged from 18 to 560 times higher than their respective criteria. However, attenuating circumstances such as dilution and storm duration must be taken into account in order to fully evaluate the significance of these exceedances. Since most storms last between 2 and 16 hours, violations of 24-hour chronic criteria levels appear to be unlikely. The long-term effects on aquatic life of these pollutants bound to sediments, however, are unknown. These five pollutants, especially lead, may accumulate to some degree in sediments. Reservoirs and slowly flushing bays will tend to accumulate these pollutants. The degree of impacts from such accumulation is not known.

One final observation can be made regarding toxic metal problems in runoff and receiving stream waters. Many metals appear to be bound to organic matter or mineral particulates in water or bottom sediments. Through desorbtion they are potentially available for movement in a soluble form into the water column. In many cases desorbtion is governed by the physical-chemical parameters of pH, oxidation-reduction potential (EH), and dissolved oxygen (DO). Low (acid) pH, EH, and DO favor solubility. Current research on acid precipitation suggests that the pH and possibly the EH of stormwater in many locations is decreasing. Consequently, a trend towards increased concentrations of soluble metals and therefore increased toxicity of these metals in the water would be expected under these conditions.

SECTION 6

SPECIAL METALS SAMPLING PROJECT

INTRODUCTION

The Special Metals Project was initiated to enhance the usefulness of the NURP priority pollutant metals data base and to provide additional perspective on the potential toxicity of priority pollutant metals in urban runoff. The primary objective of this project was to determine the relationship among dissolved, total, and total recoverable concentrations of 29 metals (Table 13), including both priority and non-priority pollutant metals, and to evaluate the potential impact of priority pollutant metals in urban runoff on aquatic life and water supplies. A secondary objective was to ensure a uniform level of quality in the generated data by having all of the metal analysis conducted at a single laboratory. This project, therefore, expands the NURP priority pollutant metals data base which provides results for only one form (or fraction) of each metal's concentration, and which uses numerous laboratories.

Definitions of the three metal fractions analyzed in this project are given below:

- Dissolved metals - those constituents (metals) which will pass through a 0.45 micron membrane filter. Occasionally referred to as "soluble" metal content.
- Total recoverable metals - the concentration of metals in an unfiltered sample following treatment with hot dilute mineral acid. Occasionally referred to as "extractable" metal content.
- Total metals - the concentration of metals determined in an unfiltered sample following vigorous digestion with concentrated nitric acid.

The three forms of metal are identified and quantified because: (1) in most cases, aquatic life toxicity is believed to be directly related to the amount of dissolved metal available, and (2) total recoverable and total metals results are directly comparable to EPA water quality criteria and drinking water standards, respectively (Appendix D). The dissolved metal fraction is most directly related to toxicity, however criteria and standards are based on total metals fractions because they provide an indication of the amount of metal available for dissolution.

Table 13

Special Metals Project: Parameter List

Priority Pollutant Metals	Non-Priority Pollutant Metals
Arsenic (As)	Aluminum (Al)
Beryllium (Be)	Barium (Ba)
Cadmium (Cd)	Boron (B)
Chromium (Cr)	Calcium (Ca)
Copper (Cu)	Cobalt (Co)
Lead (Pb)	Iron (Fe)
Mercury (Hg)	Lithium (Li)
Nickel (Ni)	Magnesium (Mg)
Selenium (Se)	Manganese (Mn)
Silver (Ag)	Molybdenum (Mo)
Thallium (Tl)	Potassium (K)
Zinc (Zn)	Sodium (Na)
	Strontium (Sr)
	Tin (Sn)
	Titanium (Ti)
	Vanadium (V)
	Yttrium (Y)

EPA's 1980 water quality criteria for priority pollutant metals are based on laboratory toxicity tests in which the actual form of the metal as measured in concentration may not be known with certainty; most of these tests were probably conducted using metals in the more toxic, dissolved form. The criteria for metals, however, are expressed in terms of total recoverable metal in an effort to provide adequate protection of aquatic life. This fraction was selected as the basis for the criteria because: (1) the actual form of the metal reported in laboratory toxicity tests may not be known, and (2) metals in the aquatic environment may undergo reactions which convert various forms of the metal into the dissolved fraction. EPA's drinking water standards, however, are based on the total metals fraction. Consequently, to identify potential effects of urban runoff on aquatic life and on water supplies, a comparison of both total recoverable and total metal concentrations against respective criteria and standards is required.

As part of this project, 17 non-priority pollutant metals were also measured in the three fractions since the selected analytical procedure provided this data at no additional cost. These data are available to all NURP cities and may be analyzed in future EPA NURP assessments where parameters beyond the current priority pollutant list are investigated. The concentrations of three of these metals (Ca, Mg, and Sr) were used to calculate hardness for each sample. These hardness values were then used to calculate the applicable EPA water quality criteria for selected priority pollutant metals with hardness-dependent criteria.

METHODOLOGY

Twenty-five NURP cities expressed an interest in participating in this program (Table 14 and Figure 3). These cities were supplied sampling kits with sufficient supplies to collect eight runoff samples for each of the three fractions. Consequently, a potential maximum of 200 samples could have been analyzed for each of the three fractions. Along with the sampling kit, a sampling manual and recommendations on sampling were provided. These recommendations are as follows:

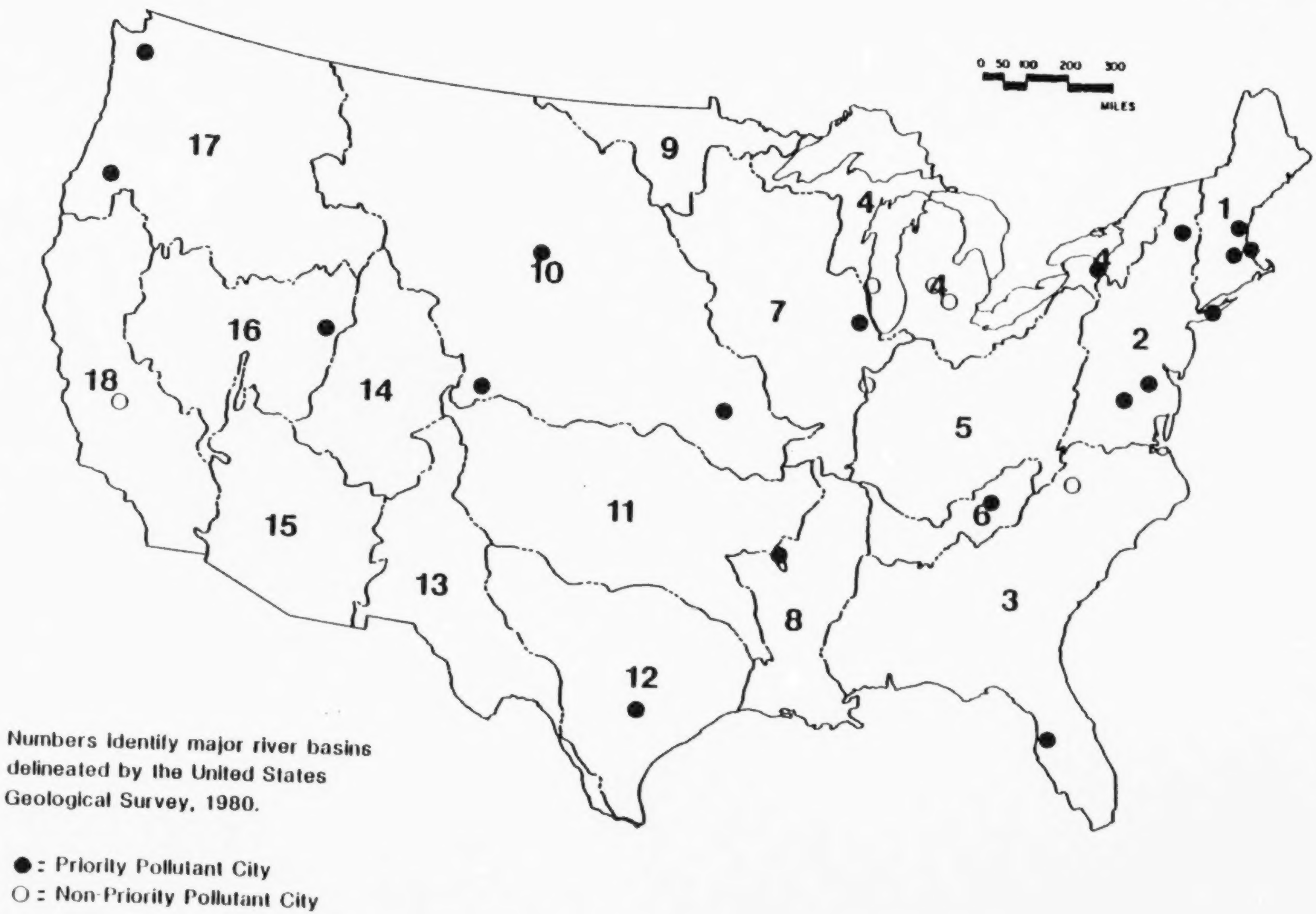
1. The samples collected should be either flow-composited or a series of discrete samples for a runoff event.
2. The special metals sample may be split out of the sample collected for priority pollutant analysis, or for those cities not participating in the toxic sampling program, the sample may be split out of a sample collected for conventional pollutant analysis.

Table 14

NURP Cities Participating in the Special Metals Sampling Project

Durham, NH*
Lake Quinsigamond, MA*
Mystic River, MA*
Irondequoit Bay, NY*
Lake George, NY*
Long Island, NY*
Baltimore, MD*
Washington, DC*
Knoxville, TN*
Tampa, FL*
Winston-Salem, NC
Champaign-Urbana, IL
Milwaukee, WI
Chicago, IL*
Tri-County, MI
Washtenaw, MI
Austin, TX*
Little Rock, AR*
Kansas City, MO*
Denver, CO*
Rapid City, SD*
Salt Lake City, UT*
Fresno, CA
Bellevue, WA*
Eugene, OR*

*Also participating in the NURP priority pollutant sampling program.


0 50 100 200 300
MILES
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18

Numbers identify major river basins delineated by the United States Geological Survey, 1980.

● : Priority Pollutant City
○ : Non-Priority Pollutant City

Figure 3. NURP Special Metals City Locations

At the conclusion of this monitoring program (June 15, 1982), 20 cities had supplied samples. Several of these cities had not provided the maximum allotted number of samples and two cities had requested and were allotted additional samples. In summary, one hundred forty-seven samples were analyzed and these results are assessed in this final report.

The analytical methods followed by the contracted laboratory are in accordance with the EPA approved procedures published in Methods for Chemical Analysis of Water and Wastes (USEPA, 1979), and Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes (USEPA, 1980). Table 15 summarizes the analysis procedures used and references the EPA methods and analytical detection limits for each metal. The use of the Inductively Coupled Plasma-Atomic Emission Spectrometric Method (ICP) for trace element analysis of runoff samples provides a multi-element analysis at no additional cost. Therefore, besides data on the priority pollutant metals, which are of primary concern, data on 17 additional metal elements are provided.

Four data analysis approaches are used to summarize preliminary results:

1. Metals (composite samples only) are identified by frequency of detection, including calculations of geometric mean concentrations of each fraction (total, total recoverable, and dissolved).

2. Comparisons are made of priority pollutant metals concentrations (total recoverable and total metal) of undiluted urban runoff with EPA's water quality criteria and drinking water standards, respectively. These comparisons identify exceeded criteria and standards in an effort to evaluate the potential downstream effects on aquatic life as well as the potential impacts on water supplies.

   EPA water quality criteria for the protection of aquatic life are of two types: (1) "acute" represents the maximum concentration of a pollutant at any time; (2) "chronic" represents the maximum 24-hour average concentration allowed.

   Those criteria that are hardness dependent were adjusted using the hardness values calculated for each water sample using Ca, Mg and Sr concentrations. (Hardness values ranged from 8.7 to 699 with an arithmetic mean of approximately 109 mg/l.)

Table 15

Summary of Analytical Procedures Used in the Special Metals Sampling Program

Metal	Method Analysis	Reference No.	Detection Limit ug/l
Arsenic (As)	Furnace AA (1)	206.2 (2)	10
Beryllium (Be)	ICP (3)	200.7 (4)	2
Cadmium (Cd)	ICP (3)	200.7 (4)	5
Chromium (Cr)	ICP (3)	200.7 (4)	10
Copper (Cu)	ICP (3)	200.7 (4)	20
Lead (Pb)	ICP (3)	200.7 (4)	40
Mercury (Hg)	Cold Vapor AA (5)	245.1 (2)	1
Nickel (Ni)	ICP (3)	200.7 (4)	20
Selenium (Se)	Furnace AA (1)	270.2 (2)	10
Silver (Ag)	ICP (3)	200.7 (4)	10
Thallium (Tl)	Furnace AA (1)	279.2 (2)	10
Zinc (Zn)	ICP (3)	200.7 (4)	10
Aluminum (Al)	ICP (3)	200.7 (4)	50
Barium (Ba)	ICP (3)	200.7 (4)	10
Boron (B)	ICP (3)	200.7 (4)	10
Calcium (Ca)	ICP (3)	200.7 (4)	100
Cobalt (Co)	ICP (3)	200.7 (4)	10
Iron (Fe)	ICP (3)	200.7 (4)	20
Lithium (Li)	ICP (3)	200.7 (4)	10
Magnesium (Mg)	ICP (3)	200.7 (4)	100
Manganese (Mn)	ICP (3)	200.7 (4)	10
Molybdenum (Mo)	ICP (3)	200.7 (4)	10
Potassium (K)	ICP (3)	200.7 (4)	200
Sodium (Na)	ICP (3)	200.7 (4)	100
Strontium (Sr)	ICP (3)	200.7 (4)	10
Tin (Sn)	ICP (3)	200.7 (4)	50
Titanium (Ti)	ICP (3)	200.7 (4)	10
Vanadium (V)	ICP (3)	200.7 (4)	10
Yttrium (Y)	ICP (3)	200.7 (4)	10

Footnotes:

[1] Atomic Absorption, Furnace Technique.

[2] U.S. Environmental Protection Agency. 1979. Methods for the Chemical Analysis of Water and Wastes. Environmental Monitoring and Support Laboratory. Office of Research and Development. Cincinnati, Ohio.

[3] Inductively Coupled Plasma-Atomic Emission Spectrometric Method.

[4] U.S. Environmental Protection Agency. 1980. Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes. Environmental Monitoring and Support Laboratory. Office of Research and Development. Cincinnati, Ohio.

[5] Manual Cold Vapor Atomic Absorption Technique.

3. Comparisons are made of dissolved metals concentrations with total and total recoverable concentrations to identify the relative importance of each fraction for each metal.

4. Comparisons are made of non-priority pollutant metal concentrations (total metal) found in undiluted urban runoff with EPA's "Red Book" Criteria.

At this time, the focus of the data analysis is on the priority pollutant metals. A range of the geometric mean was calculated for each parameter, based on assumptions made in the EPA-Water Planning Division report "Preliminary Results of the NURP Program." Since it is not appropriate to calculate a mean if most of the values are undetected, only metals found in at least 10 percent of the samples are included in this analysis. Two geometric means were computed to identify a range within which the actual mean falls. The upper end of the range was calculated using the actual detection limit when the pollutant was undetected. The lower end was calculated using a very small number (0.1 times the detection limit) for the undetectable (remarked) result in order to avoid zero, which cannot be accommodated in geometric mean calculations.

Mean concentrations were only calculated on composite samples; therefore, the total sample size was 109. The 38 discrete samples were excluded because they do not provide an adequate representation of the runoff event concentration. The data analysis used event mean concentration which is calculated by dividing the mass discharge, whether it be total, total recoverable, or dissolved, by the total runoff volume. If a flow-weighted composite was collected, the metal concentration was used to represent the event mean concentration. No flow data were reported for discrete samples and, consequently, event mean concentrations could not be calculated. These discrete samples did provide data on the instantaneous metal content of various periods in a runoff event and were used in determining the percent of total metal in the various metal fractions.

FINDINGS

Discrete and composite raw sampling data for all pollutants were compiled and composite data is summarized in Table 16. Appendix E of this document contains information regarding quality control data generated concurrently with the analysis of the special metals samples. Three separate items are included:

- Results of an external quality assurance audit of the contract laboratory conducted by EPA-EMSL in Cincinnatti, Ohio.

Table 16

Summary of Number of Detections, Mean Concentrations, Range and Detection Limits for Special Metals Data Collected from March 1981 to June 1982 (Composite Samples Only - 109 Samples: concentrations in ug/l)

Pollutant	Form	Number of Detected Values	Geometric Mean RMK = 0.10 RMK*	Geometric Mean RMK = RMK*	Range of Detected Values	Detection Limit
Arsenic	Total	13	1	11	10 - 130	10
	Total Recoverable	5	-	-	10 - 40	10
	Dissolved	1	-	-	10	10
Beryllium	Total	4	-	-	2	2
	Total Recoverable	3	-	-	2	2
	Dissolved	1	-	-	2	2
Cadmium	Total	5	-	-	5	5
	Total Recoverable	4	-	-	5	5
	Dissolved	2	-	-	5 - 10	5
Chromium	Total	52	4	14	10 - 110	10
	Total Recoverable	44	3	13	10 - 100	10
	Dissolved	2	-	-	10 - 20	10
Copper	Total	54	10	31	20 - 520	20
	Total Recoverable	54	10	31	20 - 520	20
	Dissolved	22	4	24	20 - 380	20
Lead	Total	69	45	105	40 - 28,000	40
	Total Recoverable	69	47	107	40 - 28,700	40
	Dissolved	7	5	46	40 - 1,620	40
Mercury	Total	3	-	-	1-5	1
	Total Recoverable**	-	-	-	-	-
	Dissolved	2	-	-	1	1
Nickel***	Total	21	4	23	20 - 120	20
	Total Recoverable	12	3	22	20 - 100	20
	Dissolved	2	2	21	20 - 140	20
Selenium	Total	0	-	-	-	10
	Total Recoverable	0	-	-	-	10
	Dissolved	0	-	-	-	10
Silver	Total	0	-	-	-	10
	Total Recoverable	0	-	-	-	10
	Dissolved	0	-	-	-	10

*RMK = REMARK and indicates non-detection.

**There were no data for total recoverable mercury.

***Contamination suspected in dissolved fraction.

Table 16 (Cont.)

Summary of Number of Detections, Mean Concentrations, Range and Detection Limits for
Special Metals Data Collected from March 1981 to June 1982
(Composite Samples Only - 109 Samples: concentrations in ug/l)

Pollutant	Form	Number of Detected Values	Geometric Mean RMK = 0.10 RMK*	Geometric Mean RMK = RMK*	Range of Detected Values	Detection Limit
Thallium	Total	0	-	-	-	10
	Total Recoverable	0	-	-	-	10
	Dissolved	0	-	-	-	10
Zinc	Total	100	102	124	10 - 5,750	10
	Total Recoverable	101	113	131	10 - 5,640	10
	Dissolved	92	37	51	10 - 2,340	10
Aluminum	Total	108	2,250	2,300	50 - 100,000	50
	Total Recoverable	108	1,610	1,610	50 - 85,700	50
	Dissolved	36	13	62	50 - 1,400	50
Barium	Total	105	48	52	10 - 1,310	10
	Total Recoverable	101	40	47	10 - 1,060	10
	Dissolved	94	37	48	10 - 350	10
Boron**	Total	82	17	30	10 - 950	10
	Total Recoverable	74	21	43	10 - 200	10
	Dissolved	94	27	36	10 - 230	10
Calcium	Total	109	23,800	23,800	2,900 - 245,000	100
	Total Recoverable	108	23,500	23,500	100 - 238,000	100
	Dissolved	107	17,700	17,700	100 - 153,000	100
Cobalt	Total	8	1	11	10 - 50	10
	Total Recoverable	9	1	11	10 - 40	10
	Dissolved	0	-	-	-	10
Iron	Total	109	3,250	3,250	140 - 97,800	20
	Total Recoverable	108	2,630	2,630	20 - 91,200	20
	Dissolved	34	36	59	20 - 1,240	20
Lithium	Total	29	2	13	10 - 1,140	10
	Total Recoverable	27	2	13	10 - 1,200	10
	Dissolved	16	2	12	10 - 1,300	10
Magnesium	Total	109	5,700	5,700	600 - 31,900	100
	Total Recoverable	108	5,550	5,550	500 - 27,300	100
	Dissolved	107	3,430	3,430	300 - 28,500	100

*RMK = REMARK and indicates non-detection.

**Contamination suspected in dissolved fraction.

Table 16 (Cont.)

Summary of Number of Detections, Mean Concentrations, Range and Detection Limits for
Special Metals Data Collected from March 1981 to June 1982
(Composite Samples Only - 109 Samples: concentrations in ug/l)

Pollutant	Form	Number of Detected Values	Geometric Mean RMK = 0.10 RMK*	Geometric Mean RMK = RMK*	Range of Detected Values	Detection Limit
Manganese	Total	107	141	147	10 - 4,200	10
	Total Recoverable	106	139	145	10 - 4,150	10
	Dissolved	78	16	30	10 - 290	10
Molybdenum	Total	6	-	-	10 - 20	10
	Total Recoverable	2	-	-	10	10
	Dissolved	1	-	-	10	10
Potassium	Total	109	3,300	3,300	600 - 26,000	200
	Total Recoverable	108	3,080	3,080	200 - 20,000	200
	Dissolved	105	3,050	3,190	2,000 - 18,600	200
Sodium	Total	109	8,190	8,190	700 - 142,000	100
	Total Recoverable	108	8,210	8,210	700 - 148,000	100
	Dissolved	107	9,280	9,280	900 - 160,000	100
Strontium	Total	109	92	92	10 - 4,490	10
	Total Recoverable	108	91	91	10 - 4,290	10
	Dissolved	107	74	74	10 - 5,200	10
Tin	Total	3	-	-	50	50
	Total Recoverable	0	-	-	-	50
	Dissolved	0	-	-	-	50
Titanium	Total	93	56	78	10 - 2,620	10
	Total Recoverable	95	51	67	10 - 2,250	10
	Dissolved	2	-	-	10 - 20	10
Vanadium	Total	37	3	14	10 - 190	10
	Total Recoverable	34	3	13	10 - 170	10
	Dissolved	1	-	-	30	10
Yttrium	Total	8	1	11	10 - 50	10
	Total Recoverable	10	1	11	10 - 60	10
	Dissolved	0	-	-	-	10

*RMK = REMARK and indicates non-detection.

- Summary internal laboratory quality control data generated with the batch analysis of the special metals samples.

- A detailed description of the significance of the quality control data and the method of calculation.

Specific results and findings are summarized below:

1. Nine priority pollutant metals were detected in the total fraction of the 109 composite samples. Their frequency of detection and range of values are shown below. The range surrounding the geometric mean is also provided for the metals found in at least 10% of the samples.

	Frequency Found Above Detection Limit (%)	Range of Detected Values (ug/l)	Range of Geometric Mean* (ug/l)
Arsenic	12	10-130	1-11
Beryllium	4	2	-
Cadmium	5	5	-
Chromium	49	10-110	4-14
Copper	50	20-520	10-31
Lead	63	40-28,000	45-105
Mercury	3	1	-
Nickel	19	20-120	4-23
Zinc	92	10-5,750	102-124

* Based on "total metal" values presented in Table 16.

2. Comparisons of total recoverable concentrations (undiluted by stream flow) with EPA water quality criteria and drinking water standards, respectively, reveal that lead, copper, and zinc exceed acute criteria in greater than 34 percent of the samples while they exceed chronic criteria in greater than 53 percent of the samples (Table 17). Lead concentrations were found to exceed EPA's drinking water standards in 37 percent of the samples.

3. Comparison of the priority pollutant metals by fraction (Table 18) revealed that, in general, metals are primarily in the suspended form and are removed from the sample by 0.45 Micron filtration. However, both copper and zinc have significant amounts (∿40%) of dissolved constituents. For the non-priority metals (Table 19) several elements are found primarily (∿80%) in the dissolved fraction (e.g., potassium, magnesium, lithium, strontium, boron, and sodium).

Table 17

Summary of Water Quality Criteria Violations[a]

Metal	# of Samples	Percentage of Samples In Violation			
		Freshwater Acute	Freshwater Chronic	Human Health	Drinking Water Standard
Arsenic	147	0	0	5^{c}	3
Beryllium	147	0	0	2^{c}	NS
Cadmium	147	4^{c}	4^{c}	0	0
Chromium	147	0	4	0	4
Copper	147	40^{c}	53^{b,c}	NCA	0
Lead	147	40^{c}	66^{b,c}	37^{b}	37^{b}
Mercury[d]	147	2	5^{c}	5^{c}	2
Nickel	147	0	0	20^{c}	NS
Selenium	147	0	0	0	0
Silver	147	0^{c}	0^{c}	0	0
Thallium	147	0	0	0	0
Zinc	147	34^{b}	86^{b}	NCA	1

Footnotes:

[a] Violations based on total recoverable fraction only.

[b] Five violations as a result of 5 discrete samples collected for a single runoff event in Long Island, NY., May 11, 1981.

[c] Detection limit is higher than criteria for the metal; therefore, the violation incidence could be higher than shown.

[d] Total fraction used for mercury.

Table 18
Total Recoverable and Dissolved Metals Concentration as a Percent of Total Metals Concentration:[1]
Priority Pollutant Metals
(Based on 147 samples)

		Percent Total Recoverable	Percent Dissolved	Frequency of Detection in Total Fraction (%)
Arsenic[2]	RMK[3] = 0	25	3	12
	RMK = RMK	42	29	
Beryllium[2]	RMK = 0	-	-	4
	RMK = RMK	-	-	
Cadmium[2]	RMK = 0	-	-	4
	RMK = RMK	-	-	
Chromium	RMK = 0	79	2	48
	RMK = RMK	88	42	
Copper	RMK = 0	98	40	53
	RMK = RMK	99	62	
Lead	RMK = 0	100	7	67
	RMK = RMK	100+	15	
Mercury[2]	RMK = 0	-	-	4
	RMK = RMK	-	-	
Nickel[4]	RMK = 0	60	17	20
	RMK = RMK	85	79	
Selenium[2]	RMK = 0	-	-	0
	RMK = RMK	-	-	
Silver[2]	RMK = 0	-	-	0
	RMK = RMK	-	-	
Thallium[2]	RMK = 0	-	-	0
	RMK = RMK	-	-	
Zinc	RMK = 0	85	43	94
	RMK = RMK	85	43	

[1] Determined using only those samples with a detectable level of metal in the total fraction for greater than 10% of the samples analyzed.

[2] Fewer than 10% of the samples had detectable levels of metal in the total fraction.

[3] RMK = 0: Percentages have been calculated substituting zero for less than detectable values in the dissolved and total recoverable fractions.

RMK = RMK: Percentages have been calculated substituting the detectable limit for less than detectable values in the dissolved and total recoverable fractions.

[4] One data point eliminated from data set due to field contamination.

Table 19
Total Recoverable and Dissolved Metals Concentration as a Percent of Total Metals Concentration:[1] Non-Priority Pollutant Metals
(Based on 147 samples)

		Percent Total Recoverable	Percent Dissolved	Frequency of Detection in Total Fraction (%)
Aluminum	RMK[3] = 0	75	1	100
	RMK = RMK	75	1	
Barium	RMK = 0	91	75	96
	RMK = RMK	91	76	
Boron[4]	RMK = 0	81[5]	100+	69
	RMK = RMK	100+	100+	
Calcium	RMK = 0	98	66	100
	RMK = RMK	98	66	
Cobalt[2]	RMK = 0	-	-	6
	RMK = RMK	-	-	
Iron	RMK = 0	86	1	100
	RMK = RMK	86	1	
Lithium	RMK = 0	96	80	27
	RMK = RMK	98	92	
Magnesium	RMK = 0	98	67	100
	RMK = RMK	98	67	
Manganese	RMK = 0	98	15	99
	RMK = RMK	98	16	
Molybdenum[2]	RMK = 0	-	-	9
	RMK = RMK	-	-	
Potassium	RMK = 0	91	81	100
	RMK = RMK	91	82	
Sodium	RMK = 0	99	100+	100
	RMK = RMK	99	100+	

Table 19 (Cont.)

Total Recoverable and Dissolved Metals Concentration as a Percent of Total Metals Concentration[1]: Non-Priority Pollutant Metals

(Based on 147 samples)

		Percent Total Recoverable	Percent Dissolved	Frequency of Detection in Total Fraction (%)
Strontium	RMK = 0	97	85	100
	RMK = RMK	97	85	
Tin[2]	RMK = 0	-	-	5
	RMK = RMK	-	-	
Titanium	RMK = 0	81	0	86
	RMK = RMK	81	4	
Vanadium	RMK = 0	75	1	42
	RMK = RMK	79	30	
Yttrium[2]	RMK = 0	-	-	5
	RMK = RMK	-	-	

[1] Determined using only those samples with a detectable level of metal in the total fraction for greater than 10% of the samples analyzed.

[2] Fewer than 10% of the samples had detectable levels of metal in the total fraction.

[3] RMK = 0: Percentages have been calculated substituting zero for less than detectable values in the dissolved and total recoverable fractions.

RMK = RMK: Percentages have been calculated substituting the detectable limit for less than detectable values in the dissolved and total recoverable fractions.

[4] Contamination suspected in the dissolved fraction.

[5] Low percentage due to different detection limit for total recoverable relative to total data.

4. Four of the non-priority metals (barium, boron, iron and manganese) have criteria available in EPA's "Red Book" (Table 20). In undiluted runoff, barium and boron did not exceed criteria for more than 3% of the samples; iron and manganese exceeded the criteria for domestic water supplies (welfare) in 96% and 79% of the samples, respectively. These criteria are established to prevent brownish staining of laundry and plumbing fixtures and objectional taste in beverages.

CONCLUSIONS

For this preliminary screening analysis, the results indicate that zinc, lead, copper and chromium are the priority pollutant metals detected most frequently and at the highest concentration.

Lead concentrations in undiluted runoff were found to exceed the drinking water standard and human health criterion of 50 ug/l (total lead) in 37 percent of the samples, with detected total lead concentrations ranging from 40-28,000 ug/l. Although dilution by receiving streams and subsequent treatment of river water by drinking water facilities would likely reduce these levels (particularly since it is in the suspended form), drinking water standard violations are still possible under worst case conditions. Such conditions would include cases where: (1) the runoff during a storm event was a large portion of the receiving water flow, resulting in a dilution of less than 1 to 15; (2) the preliminary sampling results were representative of lead concentrations above drinking water supply intakes; and (3) lead removal by public drinking water treatment facilities was minimal. Specific risks to drinking water supplies could be evaluated by confirmatory sampling during storm events.

In undiluted urban runoff, nickel concentrations exceed the human health criterion of 13.4 ug/l (total nickel) in 20 percent of the samples, with total detected nickel concentrations ranging from 20-120 ug/l. Violations are expected to be less than the 20 percent figure after dilution by receiving streams. Moreover, nickel is not considered a significant human health problem in water because it is poorly adsorbed by the body when ingested. Inhalation of nickel, especially nickel carbonyl, poses the greatest risk to human health.

Lead, copper and zinc concentrations in undiluted runoff exceed freshwater acute criteria in more than 34 percent of the samples. The largest observed concentrations are approximately 25 times the respective criteria (One lead

Table 20

Summary of Violations of EPA's
"Red Book" Criteria for
Non-Priority Pollutant Metals (1)
(In undiluted Urban Runoff - 147 samples)

Metal	Criteria (ug/l)	Number of Samples	Range of Detected Values (ug/l)	% of Samples In Violation	Detection Limit (ug/l)
Barium	1000 (2)	147	10-1,310	3	10
Boron	750 (3)	147	10-950	< 1	10
Iron	300 (4)	147	200-97,800	96	20
Manganese	50 (4)	147	10-4,200	79	10

[1] Violations based on total metal fraction only.

[2] Domestic water supply (health)

[3] Long term irrigation on sensitive crops

[4] Domestic water supplies (welfare)

value exceeded its criteria by a factor of 160). Depending upon dilution in the receiving stream, these pollutants could be harmful to aquatic life.

Lead, copper and zinc concentrations in undiluted runoff also exceed freshwater chronic criteria in more than 53 percent of the samples. These criteria represent allowable levels for 24 hours. Consequently, duration of the storm event and receiving stream flow are both important factors needed to fully evaluate the significance of these violations. Since most storms last between 2 and 16 hours, problems due to chronic criteria violations appear to be unlikely. The violations of acute criteria, however, could be significant in longer term storms with low dilutions in receiving waters.

Only two priority pollutant metals (copper and zinc) were present in dissolved forms, to any appreciable extent.

This screening approach does not account for the long-term water quality impacts that might occur as a result of the depositon of sediment and accumulation of toxic metals in stream bottoms. The sediments deposited as a result of urban runoff may be a source of toxic metal pollution due to deposition and resuspension.

In undiluted urban runoff, two non-priority pollutant metals (iron and manganese) exceed EPA's "Red Book" criteria established to prevent brownish staining of laundry and plumbing fixtures, and objectionable taste in beverages. The high levels of these elements found in urban runoff is not unusual since the metals are ubiquitous in nature, and iron is the fourth most abundant element in the earth's crust.

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Appendix A - Land Use Characteristics of NURP Priority Pollutant Sites

APPENDIX A

TABLE A-1

LAND USE CHARACTERISTICS OF NURP PRIORITY POLLUTANT SITES

City	Site designation	Acres	Population	Land use (percent)[a,b]								
				1110RUR	1120LDR	1130MDR	1140HDR	1200CML	1300IND	1400PRK	1500CON	Other
1. Durham, NH[c]	1-PKG	1	0					100				
2. Lake Quinsigamond, MA	P2, Route 9	338	2,285			41	6	24	11	19		
	P3, Locust Avenue	154	1,703			85		2	8	5		
3. Mystic River, MA	EOPA	50	240		100							
	EOPB	18	0						100[d]			
4. Long Island, NY	Huntington	39	0					100				
	Plainview	190	0									100% highway and recharge basin
	Syosset	28	238			100						
	Laurel Hollow	100	117		100							
	Center Reach	69	0					100				
7. Washington, DC	DC151UR9 Fairidge	19				88						12%-1401
	DC151UR10 Stedwick	27			2	75						22%-1401
	DC151UR15 Westleigh	41			93					7		
	DC151UR17 Burke Shop. Ctr.	5						82		18		
	DC151UR3 Burke Pond	18				100						
	DC151UR19 Rockville Ctr.	4								26		74%-1401
	DC151UR6 Stratton Woods	8			100							
	DC151UR5 Dandridge	2					100					
	DC151UR7 Lake Ridge	68										
	DC151UR13 Bulk Mail Fac.	20										100%-1401
8. Baltimore, MD	Hampden	16.9	945				84	16				
	Mt. Washington	19.6	154			86				14		
12. Knoxville, TN	CBD	26										
	R1	68										
	R2	89										
	Strip Commercial	187										
17. Glen Ellyn, IL	Main Inlet	534	4,200		80	3		5		5		5%-1401; 2%-6000
	Main Outlet	Outlet from detention basin										

(continued)

TABLE A-1. (continued)

City	Site designation	Acres	Population	Land use (percent)[a,b]								
				1110RUR	1120LDR	1130MDR	1140HDR	1200CML	1300IND	1400PRK	1500CON	Other
19. Austin, TX	TX1001 Hart Lane (Northwest Austin)	378	3,500			97	3	<1				
	TX1002 Rollingwood	60	200		100							
20. Little Rock, AR	AR1040 Rock @ 36th	10,074	23,412			31[g]		6		5		4%-2000 53%-4000 2%-7000
	AR1020 Rock @ Markham	5,265	537			8[g]				3		8%-2000 78%-4000 2%-7000
	AR1053 Fourche @ Hwy. 5											
	AR1063 Fourche @ Univ.											
	AR1073 Fourche @ Lindsey											
21. Kansas City, KS	RR Rock Creek Residential	58	457			100						
	RC Rock Creek Commercial	36	122			50		50				
	IC Indian Creek Com.	58						96				4% Vacant
	II Indian Creek Ind.	72							56			44% Vacant
22. Denver, CO	Denver Fed. Ctr. (inflow)	69	631				33(MFR)	30		37		
	Asbury Park (inflow)	121	1,115			86(SFR)		14				
	Villa Italia	74	0					100				
	Big Dry Creek	33	637				100(MFR)					
23. Salt Lake City, UT	8th South @ Jordan, South											
	8th South @ Jordan, Middle	2,048	10,761		29	1		8	14	18		3%-1401
	8th South @ Jordan, North											
	13th South @ Jordan, South	9,948	58,110	7	4	2		5	8	43	2	4%-1401 3%-1600 22%-4000
	13th South @ Jordan, North											
	North Temple @ Jordan	4,096	10,410	8	11	1			3	54		4%-1401 18%-4000
24. Rapid City, SD	Rapid Creek @ Canyon Lk.	33,574										100%-4000
	Rapid Creek @ Rapid City	4,090				20[g]			10			70%-3000
	Rapid Creek @ Hawthorn Ditch	1,459				10[g]		20				70%-2000 & 3000
	Meade Street Drain	1,997				65[g]		5			1	23%-3000; 6%-4000

TABLE A-1. (continued)

City	Site designation	Acres	Population	Land use (percent)[a,b] 1110RUR	1120LDR	1130MDR	1140HDR	1200CML	1300IND	1400PRK	1500CON	Other
26. Fresno, CA	00 Single Residential	94	1,000		9	87						4%-7000
	01 Multiple Residential	46	1,180				87					13%-7000
	02 Commercial	57	0					100				
	03 Industrial	278	0						66			34%-7000
27. Bellevue, WA	Lake Hills	102	1,185			90						10%-1401
	Surrey Downs	95	822			100						
28. Eugene, OR	Polk	771				33	6	44	9	6		1%-1401
	A-3 Bertelsen	1,056						9	49	41		

[a] Land use classifications according to the NURP Data Management Manual (see Key to Table A-1 on next page). Land uses are identified to Level III, except for Urban Institutional, which is identified to 1401, Level IV, to distinguish it from parkland.

[b] Percentages may not total to 100 due to rounding.

[c] Numbering of cities conforms to NURP convention.

[d] Light industrial; site is an industrial office park.

[e] Identified as multi-family residential; dwelling unit densities not specified.

[f] Identified as single family residential; dwelling unit densities not specified.

[g] Identified as residential only; dwelling unit densities not specified.

KEY TO TABLE A-1

NURP LAND USE DESIGNATIONS

Level I	Level II	Level III	Level IV
1000 Urban	1100 Residential	1110 Rural and pasture (< 1/2)[a]	(further breakdown as required)
		1120 Low-density residential (1/2 - 2)	
		1130 Medium-density residential (3-8)	
		1140 High-density residential (9+)	
	1200 Commercial	1200 Commercial business	1201 Central district
			1202 Strip (linear) development
			1203 Shopping center
	1300 Industrial	1300 Industrial	1301 Light
			1302 Medium
			1303 Heavy
	1400 Parkland or open space	1400 Parkland or open space	1401 Institutional
			1402 Parks
	1500 Under construction	1500 Under construction	
2000 Agriculture			
3000 Rangeland			
4000 Forest			
5000 Water	5100 Streams/canals		
	5200 Lakes		
	5300 Reservoirs		
	5400 Bays/estuaries		
	5500 Oceans		
6000 Wetlands			
7000 Barren			
8000 Other			

Land use classifications from NURP Data Management Manual.

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[a] Numbers in parentheses = number of dwelling units/acre.

Appendix B - Summary of EPA Ambient Water Quality Criteria

SUMMARY OF EPA AMBIENT WATER QUALITY CRITERIA

November 9, 1981

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EPA Ambient Water Quality Criteria

The following tables summarize the ambient water quality criteria developed and published by EPA in the November, 1980 Ambient Water Quality Criteria Documents (EPA-440/5-80 Series). These criteria were developed by EPA in compliance with Section 304(a)(1) of the Clean Water Act of 1977 (P.L. 95-217) for the toxic pollutants listed under Section 307(a)(1) of the Clean Water Act. The criteria listed in the following tables were extracted from the November, 1980 Ambient Water Quality Criteria Documents with the following exceptions: the criteria presented for mercury and beryllium are the corrected criteria listed in 46 FR 40199 (August 13, 1981).

Three types of ambient water quality criteria were developed by EPA:

- criteria for the protection of human health - Table 1
- criteria for the protection of aquatic life - Table 2
- criteria for controlling undesirable taste and odor - Table 3

Ambient Water Quality Criteria for the Protection of Human Health - Table 1

Two criteria for the protection of human health were developed by EPA for each toxic pollutant. One criterion is based on the assumption that a person will ingest 2 liters of ambient water and 6.5 grams of fish products from the ambient water daily. The other criterion is based on the assumption that a person will only ingest 6.5 grams of fish products from the ambient water daily.

For those pollutants known or suspected of being human carcinogens, EPA has developed criteria corresponding to several incremental lifetime cancer risk levels. A cancer risk level provides an estimate of the additional incidence of cancer that may be expected in an exposed population. A risk level of 10^{-5} for example, indicates a probability of one additional case of cancer for every 100,000 people exposed.

The criteria listed in the following table were extracted from the Mammalian Toxicology and Human Health Effects Section (Criterion Formulation Subsection) of the EPA Ambient Water Quality Criteria Documents.

Table 1
EPA AMBIENT WATER QUALITY CRITERIA (WQC) (ug/l)[1]
(For Protection of Human Health)

as of 11/9/81

	WQC for Toxicity Protection		WQC for Carcinogenicity Protection[2]					
	Ingesting Water and Organisms	Ingesting Organisms Only	Ingesting Water and Organisms			Ingesting Organisms Only		
			R = 10^{-5}	R= 10^{-6}	R = 10^{-7}	R = 10^{-5}	R = 10^{-6}	R = 10^{-7}
1. **Pesticides**								
1. Acrolein	320	780						
2. Aldrin			0.00074	0.000074	0.0000074	0.00079	0.000079	0.0000079
3. α-BHC (Alpha)			0.092	0.0092	0.00092	0.31	0.031	0.0031
4. β-BHC (Beta)			0.163	0.0163	0.00163	0.547	0.0547	0.00547
5. δ-BHC (Gamma)(Lindane)			0.186	0.0186	0.00186	0.625	0.0625	0.00625
6. γ-BHC (Delta)	NCA	NCA						
7. Chlordane			0.0046	0.00046	0.000046	0.0048	0.00048	0.000048
8. DDD (TDE)								
9. DDE (Total)			0.00024	0.000024	0.0000024	0.00024	0.000024	0.0000024
10. DDT								
11. Dieldrin			0.00071	0.000071	0.0000071	0.00076	0.000076	0.0000076
12. α-Endosulfan (Alpha)								
13. β-Endosulfan (Beta) (Total)	74	159						
14. Endosulfan Sulfate								
15. Endrin	1.0	NCA						
16. Endrin Aldehyde (Total)								
17. Heptachlor			0.00278	0.00028	0.000028	0.00285	0.00029	0.000029
18. Heptachlor Epoxide (Total)								
19. Isophorone	5,200	520,000						
20. TCDD			2.1×10^{-9}	2.1×10^{-10}	2.1×10^{-11}	2.1×10^{-9}	2.1×10^{-10}	2.1×10^{-11}
21. Toxaphene			0.0071	0.00071	0.000071	0.0073	0.00073	0.000073

Key: Refer to the last page

Table 1 (Continued)
EPA AMBIENT WATER QUALITY CRITERIA (WQC) (ug/l)[1]
(For Protection of Human Health)

as of 11/9/81

	WQC for Toxicity Protection		WQC for Carcinogenicity Protection[2]					
	Ingesting Water and Organisms	Ingesting Organisms Only	Ingesting Water and Organisms			Ingesting Organisms Only		
			$R = 10^{-5}$	$R = 10^{-6}$	$R = 10^{-7}$	$R = 10^{-5}$	$R = 10^{-6}$	$R = 10^{-7}$
II. Metals and Inorganics								
22. Antimony	146	45,000						
23. Arsenic (total trivalent)			0.022	0.0022	0.00022	0.175	0.0175	0.00175
24. Asbestos (report in fibers per liter (f/l))			00,000f/l	30,000f/l	3,000f/l	NCA	NCA	NCA
25. Beryllium			0.068	0.0068	0.00068	1.170	0.117	0.0117
26. Cadmium (Total)	10	NCA						
27a. Chromium (Total Hexavalent)	50	NCA						
27b. Chromium (Total Trivalent)	170,000	3,433,000						
28. Copper (Total)	NCA	NCA						
29. Cyanides (Free cyanide)	200	NCA						
30. Lead (Total)	50	NCA						
31. Mercury (Total)	0.144	0.146						
32. Nickel (Total)	13.4	100						
33. Selenium (Total)	10	NCA						
34. Silver (Total)	50	NCA						
35. Thallium	13	48						
36. Zinc	NCA	NCA						
III. PCBs and Related Compounds								
37-43. PCBs (Total)			0.00079	0.000079	0.0000079	0.00079	0.000079	.0000079
44. 2-Chloronaphthalene	NCA	NCA						

Key: Refer to the last page

Table 1 (Continued)

EPA AMBIENT WATER QUALITY CRITERIA (WQC) (ug/l)[1]

(For Protection of Human Health)

as of 11/9/81

	WQC for Toxicity Protection		WQC for Carcinogenicity Protection[2]					
	Ingesting Water and Organisms	Ingesting Organisms Only	Ingesting Water and Organisms			Ingesting Organisms Only		
			$R = 10^{-5}$	$R = 10^{-6}$	$R = 10^{-7}$	$R = 10^{-5}$	$R = 10^{-6}$	$R = 10^{-7}$
IV. Halogenated Aliphatics								
45. Methane, Bromo-(Methyl Bromide)			1.9	0.19	0.019	157	15.7	1.57
46. Methane, Chloro-(Methyl Chloride)			1.9	0.19	0.019	157	15.7	1.57
47. Methane, Dichloro-(Methylene Chloride)			1.9	0.19	0.019	157	15.7	1.57
48. Methane, Chlorodibromo-			1.9	0.19	0.019	157	15.7	1.57
49. Methane, Dichlorobromo-			1.9	0.19	0.019	157	15.7	1.57
50. Methane, Tribromo-(Bromoform)			1.9	0.19	0.019	157	15.7	1.57
51. Methane, Trichloro-(Chloroform)			1.9	0.19	0.019	157	15.7	15.7
52. Methane, Tetrachloro-			4.0	0.40	0.04	69.4	6.94	0.69
53. Methane, Trichlorofluoro-			1.9	0.19	0.019	157	15.7	1.57
54. Methane, Dichlorodifluoro-			1.9	0.19	0.019	157	15.7	1.57
55. Ethane, Chloro-	NCA	NCA						
56. Ethane, 1,1-Dichloro-	NCA	NCA						
57. Ethane, 1,2-Dichloro-			9.4	0.94	0.094	2,430	243	24.3
58. Ethane, 1,1,1-Trichloro-	18,400	1,030,000						
59. Ethane, 1,1,2-Trichloro-			6.0	0.6	0.06	418	41.8	4.18
60. Ethane, 1,1,2,2-Tetrachloro-			1.7	0.17	0.017	107	10.7	1.07
61. Ethane, Hexachloro-			19	1.9	0.19	87.4	8.74	0.87
62. Ethene, Chloro-(Vinyl Chloride)			20	2.0	0.2	5,246	525	52.5
63. Ethene, 1,1-Dichloro-			0.33	0.033	0.0033	18.5	1.85	0.185
64. Ethene, Trans-1,2-Dichloro-	NCA	NCA						
65. Ethene, Trichloro-			27	2.7	0.27	807	80.7	8.07
66. Ethene, Tetrachloro-			8.0	0.80	0.08	88.5	8.85	0.88
67. Propane, 1,2-Dichloro	NCA	NCA						
68. Propene, 1,3-Dichloro	87	14,100						
69. Butadiene, Hexachloro-			4.47	0.45	0.045	500	50	5.0
70. Cyclopentadiene, Hexachloro-	206	14,800						

Key: Refer to the last page

Inue

EPA AMBIENT WATER QUALITY CRITERIA (WQC) (ug/l)[1] as of 11/9/81

(For Protection of Human Health)

	WQC for Toxicity Protection		WQC for Carcinogenicity Protection [2]					
	Ingesting Water and Organisms	Ingesting Organisms Only	Ingesting Water and Organisms			Ingesting Organisms Only		
			$R = 10^{-5}$	$R = 10^{-6}$	$R = 10^{-7}$	$R = 10^{-5}$	$R = 10^{-6}$	$R = 10^{-7}$
V. Ethers								
71. Ether, Bis(Chloromethyl)-			0.0000376	0.00000376	0.000000376	0.0184	0.00184	0.000184
72. Ether, Bis(2-Chloroethyl)-			0.30	0.030	0.003	13.6	1.36	0.136
73. Ether, Bis(2-Chloroisopropyl)	34.7	4,360						
74. Ether, 2-Chloroethyl vinyl-	NCA	NCA						
75. Ether, 4-Bromophenyl Phenyl	NCA	NCA						
76. Ether, 4-Chlorophenyl Phenyl	NCA	NCA						
77. Bis(2-Chloroethoxy)methane	NCA	NCA						
VI. Monocyclic Aromatics								
78. Benzene			6.6	0.66	0.066	400	40	4
79.**Benzene, Chloro-	488	15,050						
80. Benzene, 1,2-Dichloro-								
81. Benzene, 1,3-Dichloro- (Total)	400	2,600						
82. Benzene, 1,4-Dichloro-								
83. Benzene, 1,2,4-Trichloro-	NCA	NCA						
84. Benzene, Hexachloro-			0.0072	0.00072	0.000072	0.0074	0.00074	0.000074
85. Benzene, Ethyl-	1,400	3,280						
86.**Benzene, Nitro-	19,800	2,130,000						
87. Toluene	14,300	424,000						
88. Toluene, 2,4-Dinitro-			1.1	0.11	0.011	91	9.1	0.91
89. Toluene, 2,6-Dinitro-	NCA	NCA						
VII. Phenols & Cresols								
90.**Phenol	3,500	769,000						
91. Phenol, 2-Chloro-	NCA	NCA						
92.**Phenol, 2,4-Dichloro-	3,090	26,500						
93. Phenol, 2,4,6-Trichloro-			12	1.2	0.12	36.0	3.6	0.36
94.**Phenol, Pentachloro-	1,010	29,400						
95. Phenol, 2-Nitro-	NCA	NCA						
96. Phenol, 4-Nitro-	NCA	NCA						
97. Phenol, 2,4-Dinitro-	70	14,300						
98. Phenol, 2,4-Dimethyl-	NCA	NCA						
99. m-Cresol, p-Chloro-	NCA	NCA						
100. o-Cresol, 4-6-Dinitro-	13.4	765						

Key: Refer to the last page

Table I (Continued)

EPA AMBIENT WATER QUALITY CRITERIA (WQC) (ug/l)[1]

(For Protection of Human Health)

as of 11/9/81

		WQC for Toxicity Protection		WQC for Carcinogenicity Protection[2]					
		Ingesting Water and Organisms	Ingesting Organisms Only	Ingesting Water and Organisms			Ingesting Organisms Only		
				$R = 10^{-5}$	$R = 10^{-6}$	$R = 10^{-7}$	$R = 10^{-5}$	$R = 10^{-6}$	$R = 10^{-7}$
VIII.	Phthalate Esters								
101.	Phthalate, Dimethyl-	313,000	2,900,000						
102.	Phthalate, Diethyl-	350,000	1,800,000						
103.	Phthalate, Di-n-Butyl-	34,000	154,000						
104.	Phthalate, Di-n-Octyl-	NCA	NCA						
105.	Phthalate, Bis-(2-ethylhexyl)-	15,000	50,000						
106.	Phthalate, Butyl Benzyl-	NCA	NCA						
IX.	Polycyclic Aromatic Hydrocarbons								
107.	Acenaphthene	NCA	NCA						
108.	Naphthalene	NCA	NCA						
109.	Fluoranthene	42	54						
110.	Acenaphthylene								
111.	Anthracene								
112.	Benzo(a)Anthracene								
113.	Benzo(b)Fluoranthene								
114.	Benzo(k)Fluoranthene								
115.	Benzo(ghi)Perylene								
116.	Benzo(a)Pyrene (Total)			0.028	0.0028	0.00028	0.311	0.0311	0.00311
117.	Chrysene								
118.	Dibenzo(a,h)Anthracene								
119.	Fluorene								
120.	Indeno(1,2,3-cd)Pyrene								
121.	Phenanthrene								
122.	Pyrene								
X.	Nitrosamines								
123.	Nitrosamine, Dimethyl-			0.01[illegible]	0.0014	0.00014	160	16	1.6
124.	Nitrosamine, Diphenyl-			49	4.9	0.49	161	16.1	1.61
125.	Nitrosamine, Di-n-Propyl-			0.008	0.0008	0.00008	12.4	1.24	0.124
126.	Benzidine			0.0012	0.00012	0.00001	0.0053	0.00053	0.00005
127.	Benzidine, 3,3'-Dichloro-			0.103	0.010	0.001	0.204	0.020	0.002
128.	Hydrazine, 1,2-Diphenyl-			0.422	0.042	0.004	5.6	0.56	0.056
129.	Acrylonitrile			0.58	0.058	0.006	6.5	0.65	0.065

Key: Refer to the last page

Table 1 (Continued)
EPA AMBIENT WATER QUALITY CRITERIA (WQC) (ug/l)
(For Protection of Human Health)

as of 11/9/81

KEY:

[1] 1980 EPA Ambient Water Quality Criteria for the protection of human health from the toxic properties of a pollutant ingested through water and contaminated aquatic organisms assume a daily ingestion of 2 liters of water and 6.5 grams of potentially contaimined fish products. Criteria for ingestion of contaminated aquatic organisms only assume a daily ingestion of 6.5 grams of potentially contaminated fish products.

[2] Concentrations corresponding to several incremental lifetime cancer risk levels have been estimated for those pollutants which exhibit carcinogenic and/or mutagenic effects in certain bioassay systems and which therefore are suspected of being potentially carcinogenic to humans. A risk of 10^{-5} for example, indicates a probability of one additional case of cancer for every 100,000 people exposed.

NCA = Insufficient data available upon which to derive an EPA criterion.

**An EPA Ambient Water Quality Criterion for Controlling Undesirable Taste and Odor Qualities has also been derived for this pollutant which is less than the toxicity-based criterion.

Ambient Water Quality Criteria for the Protection of Aquatic Life - Table 2

EPA has derived criteria to provide adequate protection against acute toxicity and chronic toxicity using the Guidelines for Deriving Water Quality Criteria for the Protection of Aquatic Life (45 FR (231) - November 28, 1980). For many toxic pollutants, insufficient data were available upon which to derive criteria using the Guidelines. For these pollutants, the lowest species mean acute and/or chronic toxicity values reported in the EPA Ambient Water Quality Criteria Documents are listed in the following tables. (For those Criteria Documents dealing with a single pollutant, these toxicity values were extracted from the Foreword Section; for those Criteria Documents dealing with more than one pollutant, these toxicity values were extracted from the Aquatic Life Toxicology Section).

Table 2

AMBIENT WATER QUALITY CRITERIA (ug/l)
(For Protection of Aquatic Life)

as of 11/9/81

	EPA Ambient Water Quality Criteria[1]				Lowest Reported Toxic Concentration[2]			
	Freshwater		Saltwater		Freshwater		Saltwater	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
I. **Pesticides**								
1. Acrolein	NCA	NCA	NCA	NCA	68	21	55	NDA
2. Aldrin	3.0	NCA	1.3	NCA		NDA		NDA
3. α-BHC (Alpha)	NCA	NCA	NCA	NCA	100	NDA	0.34	NDA
4. β-BHC (Beta) (Total)								
5. δ-BHC (Delta)								
6. γ-BHC (Gamma)(Lindane)	2.0	0.080	0.16	NCA				NDA
7. Chlordane	2.4	0.0043	0.09	0.0040				
8. DDD (TDE)	1.1	0.0010	0.13	0.0010				
9. DDE (Total)								
10. DDT								
11. Dieldrin	2.5	0.0019	0.71	0.0019				
12. α-Endosulfan (Alpha)	0.22	0.056	0.034	0.0087				
13. β-Endosulfan (Beta) (Total)								
14. Endosulfan Sulfate								
15. Endrin	0.18	0.0023	0.037	0.0023				
16. Endrin Aldehyde (Total)								
17. Heptachlor	0.52	0.0038	0.053	0.0036				
18. Heptachlor Epoxide (Total)								
19. Isophorone	NCA	NCA	NCA	NCA	117000	NDA	12900	NDA
20. TCDD	NCA	NCA	NCA	NCA	0.000056	NDA	NDA	NDA
21. Toxaphene	1.6	0.013	0.070	NCA				NDA

Key: Refer to the last page

Table 2 (Continued)
AMBIENT WATER QUALITY CRITERIA (ug/l)
(For Protection of Aquatic Life)

as of 11/9/81

		EPA Ambient Water Quality Criteria[1]				Lowest Reported Toxic Concentration[2]			
		Freshwater		Saltwater		Freshwater		Saltwater	
		Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
II.	**Metals and Inorganics**								
22.	Antimony	NCA	NCA	NCA	NCA	9000	1600	NDA	NDA
23.	Arsenic (Total Trivalent)	440	NCA	NCA	NCA		NDA	508	NDA
24.	Asbestos	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
25.	Beryllium	NCA	NCA	NCA	NCA	130	5.3	NDA	NDA
26.	Cadmium (Total)	3.0*	0.025*	59	4.5				
27a.	Chromium (Total Hexavalent)	21	0.29	1260	18				
27b.	Chromium (Total Trivalent)	4700*	NCA	NCA	NCA		44	10300	NDA
28.	Copper (Total)	22*	5.6	23	4.0	0.6			
29.	Cyanides (Free Cyanide)	52	3.5	NCA	NCA			30	2.0
30.	Lead (Total)	170*	3.8*	NCA	NCA			668	[illegible]5
31.	Mercury (Total)	4.1	0.20	3.7	0.10				
32.	Nickel (Total)	1800*	96*	140	7.1				
33a.	Selenium (Total Inorganic Selenite)	260	35	410	54				
33b.	Selenium (Inorganic Selenate)	NCA	NCA	NCA	NCA	760	NDA	NDA	NDA
34.	Silver (Total)	4.1*	NCA	2.3	NCA		0.12		NDA
35.	Thallium	NCA	NCA	NCA	NCA	1400	40	2130	NDA
36.	Zinc	320*	47	170	58				
III.	**PCBs and Related Compounds**								
37-43.	PCBs (General)	NCA	0.014	NCA	0.030	2.0		10	
44.	2-Chloronaphthalene	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA

Key: Refer to the last page

*Criteria calculated based on water hardness equal to 100 mg/l as $CaCO_3$. See the equations given in the Key, Note 1.

Table 2 (Continued)
AMBIENT WATER QUALITY CRITERIA (ug/l)
(For Protection of Aquatic Life)

as of 11/9/81

	EPA Ambient Water Quality Criteria[1]				Lowest Reported Toxic Concentration[2]			
	Freshwater		Saltwater		Freshwater		Saltwater	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
IV. **Halogenated Aliphatics**								
45. Methane, Bromo-(Methyl Bromide)	NCA	NCA	NCA	NCA	11,000	NDA	12,000	NDA
46. Methane, Chloro-(Methyl Chloride)	NCA	NCA	NCA	NCA	550,000	NDA	270,000	NDA
47. Methane, Dichloro-(Methylene Chloride)	NCA	NCA	NCA	NCA	193,000	NDA	256,000	NDA
48. Methane, Chlorodibromo-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
49. Methane, Dichlorobromo-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
50. Methane, Tribromo-(Bromoform)	NCA	NCA	NCA	NCA	29,300	NDA	17,900	6,400
51. Methane, Trichloro-(Chloroform)	NCA	NCA	NCA	NCA	28,900	1240	NDA	NDA
52. Methane, Tetrachloro-	NCA	NCA	NCA	NCA	35,200	NDA	50,000	NDA
53. Methane, Trichlorofluoro-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
54. Methane, Dichlorodifluoro-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
55. Ethane, Chloro-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
56. Ethane, 1,1-Dichloro-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
57. Ethane, 1,2-Dichloro-	NCA	NCA	NCA	NCA	118,000	20,000	113,000	NDA
58. Ethane, 1,1,1-Trichloro-	NCA	NCA	NCA	NCA	52,800	NDA	31,200	NDA
59. Ethane, 1,1,2-Trichloro-	NCA	NCA	NCA	NCA	36,000	9,400	NDA	NDA
60. Ethane, 1,1,2,2-Tetrachloro-	NCA	NCA	NCA	NCA	9,320	2,400	9020	NDA
61. Ethane, Hexachloro-	NCA	NCA	NCA	NCA	980	540	940	NDA
62. Ethene, Chloro-(Vinyl Chloride)	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
63. Ethene, 1,1-Dichloro-	NCA	NCA	NCA	NCA	30,300	NDA	224,000	NDA
64. Ethene, Trans-1,2-Dichloro-	NCA	NCA	NCA	NCA	135,000	NDA	NDA	NDA
65. Ethene, Trichloro-	NCA	NCA	NCA	NCA	45,000	NDA	2000	NDA
66. Ethene, Tetrachloro-	NCA	NCA	NCA	NCA	5280	840	10,200	450
67. Propane, 1,2-Dichloro	NCA	NCA	NCA	NCA	52,500	8,100	240,000	NDA
68. Propene, 1,3-Dichloro	NCA	NCA	NCA	NCA	6060	244	790	NDA
69. Butadiene, Hexachloro-	NCA	NCA	NCA	NCA	90	9.3	32	NDA
70. Cyclopentadiene, Hexachloro-	NCA	NCA	NCA	NCA	7.0	5.2	7.0	NDA

Key: Refer to the last page

Table 2 (Continued)
AMBIENT WATER QUALITY CRITERIA (ug/l)
(For Protection of Aquatic Life)

as of 11/9/81

	EPA Ambient Water Quality Criteria[1]				Lowest Reported Toxic Concentration[2]			
	Freshwater		Saltwater		Freshwater		Saltwater	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
V. Ethers								
71. Ether, Bis(Chloromethyl)-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
72. Ether, Bis(2-Chloroethyl)-	NCA	NCA	NCA	NCA	238,000	NDA	NDA	NDA
73. Ether, Bis(2-Chloroisopropyl)	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
74. Ether, 2-Chloroethyl vinyl-	NCA	NCA	NCA	NCA	354,000	NDA	NDA	NDA
75. Ether, 4-Bromophenyl Phenyl	NCA	NCA	NCA	NCA	360	122	NDA	NDA
76. Ether, 4-Chlorophenyl Phenyl	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
77. Bis(2-Chloroethoxy)methane	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
VI. Monocyclic Aromatics								
78. Benzene	NCA	NCA	NCA	NCA	5300	NDA	5100	NDA
79. Benzene, Chloro-	NCA	NCA	NCA	NCA	19500	NDA	10500	NDA
80. Benzene, 1,2-Dichloro- (see note 2)	NCA	NCA	NCA	NCA	2000	2000	1970	NDA
81. Benzene, 1,3-Dichloro-	NCA	NCA	NCA	NCA	5020	1510	2850	NDA
82. Benzene, 1,4-Dichloro-	NCA	NCA	NCA	NCA	1120	763	1990	NDA
83. Benzene, 1,2,4-Trichloro-	NCA	NCA	NCA	NCA	1500	286	450	222
84. Benzene, Hexachloro-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
85. Benzene, Ethyl-	NCA	NCA	NCA	NCA	32,000	NDA	430	NDA
86. Benzene, Nitro-	NCA	NCA	NCA	NCA	27,000	NDA	6680	NDA
87. Toluene	NCA	NCA	NCA	NCA	17,500	NDA	6300	5000
88. Toluene, 2,4-Dinitro-	NCA	NCA	NCA	NCA	31,000	NDA	NDA	NDA
89. Toluene, 2,6-Dinitro-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
VII. Phenols & Cresols								
90. Phenol	NCA	NCA	NCA	NCA	10,200	2560	5800	NDA
91. Phenol, 2-Chloro-	NCA	NCA	NCA	NCA	4380	NDA	NDA	NDA
92. Phenol, 2,4-Dichloro-	NCA	NCA	NCA	NCA	2020	365	NDA	NDA
93. Phenol, 2,4,6-Trichloro- (see note 2)	NCA	NCA	NCA	NCA	720	720	NDA	NDA
94. Phenol, Pentachloro-	NCA	NCA	NCA	NCA	55	3.2	53	34
95. Phenol, 2-Nitro-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
96. Phenol, 4-Nitro- (see note 2)	NCA	NCA	NCA	NCA	8280	NDA	12650	12650
97. Phenol, 2,4-Dinitro- (see note 2)	NCA	NCA	NCA	NCA	620	NDA	7900	7900
98. Phenol, 2,4-Dimethyl-	NCA	NCA	NCA	NCA	2120	NDA	NDA	NDA
99. m-Cresol, p-Chloro-	NCA	NCA	NCA	NCA	290	NDA	NDA	NDA
100. o-Cresol, 4-6-Dinitro-	NCA	NCA	NCA	NCA	230	NDA	NDA	NDA

Key: Refer to the last page

Table 2 (Continued)
AMBIENT WATER QUALITY CRITERIA (ug/l)
(For Protection of Aquatic Life)

as of 11/9/81

	EPA Ambient Water Quality Criteria[1]				Lowest Reported Toxic Concentration[2]			
	Freshwater		Saltwater		Freshwater		Saltwater	
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
VIII. **Phthalate Esters**								
101. Phthalate, Dimethyl-	NCA	NCA	NCA	NCA	33,000	NDA	58,000	NDA
102. Phthalate, Diethyl-	NCA	NCA	NCA	NCA	52,100	NDA	7590	NDA
103. Phthalate, Di-n-Butyl-	NCA	NCA	NCA	NCA	940	NDA	NDA	NDA
104. Phthalate, Di-n-Octyl-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
105. Phthalate, Bis-(2-ethylhexyl)-	NCA	NCA	NCA	NCA	11,100	3	NDA	NDA
106. Phthalate, Butyl Benzyl-	NCA	NCA	NCA	NCA	3,300	220	2944	NDA
IX. **Polycyclic Aromatic Hydrocarbons**								
107. Acenaphthene	NCA	NCA	NCA	NCA	1,700	NDA	970	710
108. Acenaphthylene	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
109. Anthracene	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
110. Benzo(a)Anthracene	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
111. Benzo(b)Fluoranthene	NCA	NCA	NCA	NCA	NDA	NC	NDA	NDA
112. Benzo(k)Fluoranthene	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
113. Benzo(ghi)Perylene	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
114. Benzo(a)Pyrene	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
115. Chrysene	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
116. Dibenzo(a,h)Anthracene	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
117. Fluoranthene	NCA	NCA	NCA	NCA	3980	NDA	40	16
118. Fluorene	NCA	NCA	NCA	NCA	NDA	NDA	1000	NDA
119. Indeno(1,2,3-cd)Pyrene	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
120. Naphthalene	NCA	NCA	NCA	NCA	23,000	620	2350	NDA
121. Phenanthrene	NCA	NCA	NCA	NCA	NDA	NDA	600	NDA
122. Pyrene	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
X. **Nitroxamines**								
123. Nitrosamine, Dimethyl-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
124. Nitrosamine, Diphenyl-	NCA	NCA	NCA	NCA	5850	NDA	3,300,000	NDA
125. Nitrosamine, Di-n-Propyl-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
126. Benzidine	NCA	NCA	NCA	NCA	2500	NDA	NDA	NDA
127. Benzidine, 3,3'-Dichloro-	NCA	NCA	NCA	NCA	NDA	NDA	NDA	NDA
128. Hydrazine, 1,2-Diphenyl-	NCA	NCA	NCA	NCA	270	NDA	NDA	NDA
129. Acrylonitrile	NCA	NCA	NCA	NCA	7550	NDA	NDA	NDA

Key: Refer to the last page

Table 2 (Continued)
AMBIENT WATER QUALITY CRITERIA (ug/l)
(For Protection of Aquatic Life)

as of 11/9/81

KEY:

[1] EPA Ambient Water Quality Criteria - The EPA criteria listed as "Acute" are the maximum concentrations allowed at any time. The EPA criteria listed as "Chronic" are the maximum 24-hour average concentrations allowed.

NCA = Insufficient daa available upon which to derive an EPA criterion.

EPA ambient water quality criteria for several of the toxic metals are dependent upon water hardness and are derived by the following equations:

Cadmium: freshwater acute = $e \exp(1.05 [\ln(\text{hardness})] - 3.73)$
freshwater chronic = $e \exp(1.05 [\ln(\text{hardness})] - 8.53)$
Chromium (Trivalent): freshwater acute = $e \exp(1.08 [\ln(\text{hardness})] + 3.48)$
Copper: freshwater acute = $e \exp(0.94 [\ln(\text{hardness})] - 1.23)$
Lead: freshwater acute = $e \exp(1.22 [\ln(\text{hardness})] - 0.47)$
freshwater chronic = $e \exp(2.35 [\ln(\text{hardness})] - 9.48)$
Nickel: freshwater acute = $e \exp(0.76 [\ln(\text{hardness})] + 4.02)$
freshwater chronic = $e \exp(0.76 [\ln(\text{hardness})] + 1.06)$
Silver: freshwater acute = $e \exp(1.72 [\ln(\text{hardness})] - 6.52)$
Zinc: freshwater acute = $e \exp(0.83 [\ln(\text{hardness})] + 1.95)$

[2] Lowest Reported Toxic Concentration - Insufficient data are available upon which to derive EPA criteria for many toxic pollutants. For these pollutants, the lowest species mean acute and/or chronic toxicity values reported in Section B of the relevant EPA Ambient Water Quality Criteria Document (EPA-440/5-80 Series) are listed.

NDA = Acute and/or Chronic toxicity data are not available for this pollutant. However, toxicity data may be presented in the criteria documents for structurally similar pollutants.

For the toxic pollutants 1,2-dichlorobenzene and 2,4,6-trichlorophenol, the lowest reported freshwater species mean chronic values exceed the lowest reported freshwater species mean acute values. For use in the Industrial Environmental Assessments the acute values for these two pollutants were set equal to the chronic values.

Similarly, for the toxic pollutants 4-nitrophenol and 2,4-nitrophenol, the lowest reported saltwater species mean chronic values exceed the lowest reported saltwater species mean acute values. For use in the Industrial Environmental Assessments the acute values for these two pollutants were set equal to the chronic values.

Table 3
Ambient Water Quality Criteria
For Controlling Undesirable Taste and Odor

Criteria for Controlling Undesirable Taste and Odor
have been recommended for the ten toxic pollutants
listed below using available organoleptic data

Pollutant	Criteria (ug/l)
Hexachlorocyclopentadiene	1
Chlorobenzene	20
Nitrobenzene	30
Phenol	300
2-Chlorophenol	0.1
2,4-Dichlorophenol	0.3
Pentachlorophenol	30
p-Chloro-m-Cresol	1,800
2,4-Dimethyl phenol	400
Acenaphthene	20

Appendix C - EPA Memorandum on Method Detection Limits

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL MONITORING AND SUPPORT LABORATORY
CINCINNATI, OHIO 45268

DATE: May 14, 1980

SUBJECT: Method Detection Limits for Methods 624 and 625

FROM: W. L. Budde, Chief William L. Budde
Advanced Instrumentation Section
Physical and Chemical Methods Branch

J. W. Eichelberger, Chemist James W Eichelberger
Advanced Instrumentation Section
Physical and Chemical Methods Branch

Paul Olynyk, IPA Chemist Paul Olynyk
Advanced Instrumentation Section
Physical and Chemical Methods Branch

TO: John F. Kopp, Chief
Physical and Chemical Methods Branch

Commentor #100 (Shell Oil, p. 2), Commentor #199 (American Petroleum Institute, p. 52, 59), and many other commentors questioned the detection limits given in Methods 624 and 625. In anticipation of such comments, the Environmental Monitoring and Support Laboratory - Cincinnati (EMSL-CI) proposed a procedure for the determination of the method detection limit. This draft procedure, revision 1.7, was distributed in the EPA GC/MS Users Group Newsletter of February 1980, No. 31.

The procedure was applied to approximately 95 of the Method 624/625 analytes, and eight surrogate quality control compounds in reagent water. The results of this work are shown in the attached table. All of the measurements were accomplished using the method of external calibration with a single concentration calibration standard. The concentration of the single standard was approximately the same as the expected level in the concentrated extract (Method 625) or the reagent water (Method 624). This procedure was used to minimize calibration errors and expose true method variability.

The Method 624 was used exactly as described in the Federal Register. The Method 625 was used with a few minor modifications: (a) the pH was adjusted with the use of a pH meter instead of wide range pH paper; (b) methylene chloride volumes of 75 ml, 60 ml, and 60 ml were used in place of the 60 ml, 60 ml, and 60 ml specified in Method 625; (c) methylene chloride was exchanged for acetone during the extract concentration step and concentration standards were prepared in acetone; (d) the micro K-D concentration step was replaced by repetitive washing with acetone and concentration with a gentle stream of nitrogen gas. Our general experience and the data in the attached table support the notion that these modifications are minor and have no deleterious effect on the method.

The compound N-nitrosodimethylamine is not found by Method 625 as it probably elutes with the solvent on the columns specified in the method. Therefore, this compound should be deleted from this method, and reports of its presence by analysts using this method are probably erroneous.

The compound N-nitrosodi-*n*-propylamine was observed with a mean recovery of 5% in eight measurements at the 13.3 μg/L level. This compound was stable in the acetone standard solution, and measurements in reagent water at 25 μg/L gave a mean recovery of 66% and a method detection limit of 8 μg/L.

The compound N-nitrosodiphenylamine decomposes in a hot GC injection port, and was measured as diphenylamine. Therefore, N-nitrosodiphenylamine should be deleted from this method, and reports of its presence by analysts using this method may be erroneous.

Hexachlorocyclopentadiene decomposes in the hot injection port of a GC, and it was not observed in the standard solution in acetone or in the reagent water extracts. This compound should be deleted from Method 625, and reports of its presence by analysts using this method are probably erroneous.

The compound, 1,2-diphenylhydrazine decomposes to azobenzene in the injection port and it was measured as azobenzene. The compound 1,2-diphenylhydrazine should be deleted from Method 625 and reports of its presence by analysts using this method are probably erroneous.

Benzidine was not observed at 33 μg/L and a mean recovery of 19% was observed in seven experiments at the 100 μg/L level. Additional experiments were conducted to determine the specific steps in Method 625 that cause losses of benzidine. Benzidine at 100 μg/L in methylene chloride was submitted to the sodium sulfate drying step plus the Kuderna-Danish concentration step. No acetone exchange was used and the mean recovery from the three experiments was 15%.

Therefore, although a 44 µg/L method detection limit was calculated for benzi- dine, the heavy losses observed in the drying/concentration steps indicate that this compound should be deleted from the method. Reports of benzidine by analysts using this method may be erroneous.

Five pesticides (See Table) were recovered in variable but usually zero amounts from the extracts at pH = 12. These compounds were easily measured in the standard solutions in acetone, and were observed in a series of four extracts from a pH = 7 solution. The mean percentage recoveries from reagent water at pH = 7 for the five compounds are:

alpha BHC	77.5
gamma BHC	70.8
endrin	85.8
endosulfan I	82.9
endosulfan II	88.1

The two BHC isomers each have two chlorines in a trans axial configuration with a hydrogen. This is a favorable arrangement for a base catalyzed dehydrohalogenation. These five compounds should be deleted from Method 625, and any reports of their presence by analysts using this method are probably erroneous. The EPA should provide a method 626 using a pH = 7 extraction with methylene chloride and GC/MS to identify and to measure these and similarly behaving compounds.

Only two PCB mixtures were measured, but these represent the two extremes of the various commercial product mixtures. Therefore, these measured method detection limits should be applicable to the other PCB mixtures.

It should be noted that some loss of two phenols was observed. Approximately 12% of 2,4-dimethylphenol and about 3% of 4-chloro-3-methylphenol were observed in the pH = 12 extract. This loss is small, and probably had little or no significant effect on the measured method detection limits.

Our general feeling is that detection limits measured in treated waste effluents will probably be roughly the same as those measured in reagent water. This program of measurements will be carried out during the next quarter.

Appendix D - EPA Water Quality Criteria and Standards for Toxic Metals

Table D-1

EPA Water Quality Criteria and Standards for the Toxic Metals[1]

Metal	Freshwater Acute (ug/l)[2]	Freshwater Chronic (ug/l)[2]	Human Health: Ingestion of Water and Organisms[3]	Interim Drinking Water Standard (ug/l)[4]	Anal. Detect. Limits
Arsenic	440	NCA	(0.00022)[7]	50	10
Beryllium	(130)[6]	(5.3)[6]	(0.00068)[7]	NS	2
Cadmium	3.0[5]	0.025[5]	10	10	5
Chromium	4700[5]	(44)[6]	170,000	50	10
Copper	22[5]	5.6	NCA	(1000)[8]	20
Lead	170[5]	3.8[5]	50	50	40
Mercury	4.1	0.2	0.144	2	1
Nickel	1800[5]	96[5]	13.4	NS	20
Selenium	260	35	10	10	10
Silver	4.1[5]	(0.12)[6]	50	50	10
Thallium	(1400)[6]	(40)[6]	13	NS	10
Zinc	320[5]	47	NCA	(5000)[8]	10

Key: Refer to the next page

Key:

[1] Criteria and standards for the toxic metals are based on the total recoverable metals analysis.

[2] EPA Ambient Water Quality Criteria - The EPA criteria listed as "Acute" are the maximum concentrations allowed at any time. The EPA criteria listed as "Chronic" are the maximum 24-hour average concentrations allowed.

[3] 1980 EPA Ambient Water Quality Criteria for the protection of human health from the toxic properties of a pollutant ingested through water and contaminated aquatic organisms assume a daily ingestion of 2 liters of water and 6.5 grams of potentially contaminated fish products.

[4] National Interim Primary Drinking Water Regulations for the Protection of Human Health (40 CFR: 141).

NCA = Insufficient data available upon which to derive an EPA criterion.
NS = No standard

[5] Criteria based on water hardness equal to 100 mg/l $CaCO_3$. EPA ambient water quality criteria for these toxic metals are actually dependent upon water hardness and are derived by the following equations:

Cadmium: freshwater acute $= e \exp(1.05\,[\ln(\text{hardness})] - 3.73)$
freshwater chronic $= e \exp(1.05\,[\ln(\text{hardness})] - 8.53)$
Chromium: freshwater acute $= e \exp(1.08\,[\ln(\text{hardness})] + 3.48)$
(Trivalent)
Copper: freshwater acute $= e \exp(0.94\,[\ln(\text{hardness})] - 1.23)$
Lead: freshwater acute $= e \exp(1.22\,[\ln(\text{hardness})] - 0.47)$
freshwater chronic $= e \exp(2.35\,[\ln(\text{hardness})] - 9.48)$
Nickel: freshwater acute $= e \exp(0.76\,[\ln(\text{hardness})] + 4.02)$
freshwater chronic $= e \exp(0.76\,[\ln(\text{hardness})] + 1.06)$
Silver: freshwater acute $= e \exp(1.72\,[\ln(\text{hardness})] - 6.52)$
Zinc: freshwater acute $= e \exp(0.83\,[\ln(\text{hardness})] + 1.95)$

NOTE: Hardness as mg/l $CaCO_3 = \frac{[Ca][50]}{20.0} + \frac{[Mg][50]}{12.2} + \frac{[Sr][50]}{4.38}$

[6] Lowest Reported Toxic Concentration - Insufficient data are available upon which to derive EPA criteria for many toxic pollutants. For these pollutants, the lowest species mean acute and/or chronic toxicity values reported in Section B of the relevant EPA Ambient Water Quality Criteria Document (EPA-440/5-80 Series) are listed.

[7] Beryllium and Arsenic are suspected carcinogens. Concentrations reported are for the cancer risk level of 10^{-7}. A risk of 10^{-7} indicates a probability of one additional case of cancer for every 10,000,000 people exposed.

[8] National Secondary Drinking Water Regulations for the protection of the aesthetic qualities relating to the public acceptance of drinking water (taste and odor).

Table D-2
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

AUSTIN, TX - ROLLINGWOOD   DATE: 4/17/81   HARDNESS (MG/L) 116

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.5	0.03
CHROMIUM	5483.5	
COPPER	25.4	
LEAD	205.3	5.4
NICKEL	2058.3	106.7
ZINC	362.2	
SILVER	5.2	

EUGENE, OR - A-3 @ BERTELSEN RD.   DATE: 5/5/81   HARDNESS (MG/L) 82

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	2.5	0.02
CHROMIUM	3785.4	
COPPER	18.4	
LEAD	135.1	2.4
NICKEL	1585.8	82.2
ZINC	272.4	
SILVER	2.9	

EUGENE, OR - A-3 @ BERTELSEN RD.   DATE: 5/5/81   HARDNESS (MG/L) 82

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	2.5	0.02
CHROMIUM	3785.4	
COPPER	18.4	
LEAD	135.1	2.4
NICKEL	1585.8	82.2
ZINC	272.4	
SILVER	2.9	

AUSTIN, TX. - HART LANE   DATE: 4/17/81   HARDNESS (MG/L) 123

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.8	0.03
CHROMIUM	5865.9	
COPPER	26.9	
LEAD	221.5	6.2
NICKEL	2158.3	111.8
ZINC	381.4	
SILVER	5.8	

AUSTIN, TX. - HART LANE   DATE: 4/17/81   HARDNESS (MG/L) 80

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	2.4	0.02
CHROMIUM	3709.5	
COPPER	18.1	
LEAD	132.0	2.3
NICKEL	1563.4	81.0
ZINC	268.2	
SILVER	2.8	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

BELLEVUE, WASH. - LAKE HILLS
DATE: 3/15/81
HARDNESS (MG/L) 18

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.5	0.00
CHROMIUM	722.2	
COPPER	4.4	
LEAD	20.8	0.1
NICKEL	494.3	25.6
ZINC	76.3	
SILVER	0.2	

BELLEVUE, WASH. - SURREY DOWNS
DATE: 3/15/81
HARDNESS (MG/L) 16

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.4	0.00
CHROMIUM	643.2	
COPPER	3.9	
LEAD	18.2	0.1
NICKEL	455.6	23.6
ZINC	69.8	
SILVER	0.2	

BELLEVUE, WASH. - LAKE HILLS
DATE: 3/5/81
HARDNESS (MG/L) 13

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.3	0.00
CHROMIUM	508.7	
COPPER	3.2	
LEAD	14.0	0.0
NICKEL	386.2	20.0
ZINC	58.3	
SILVER	0.1	

MILWAUKEE, WIS. - LINCOLN CREEK, 54TH
DATE: 4/8/81
HARDNESS (MG/L) 75

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	2.2	0.02
CHROMIUM	3422.2	
COPPER	16.8	
LEAD	120.5	1.9
NICKEL	1477.2	76.5
ZINC	252.1	
SILVER	2.5	

MILWAUKEE, WIS. - WOODS HOSPITAL
DATE: 4/8/81
HARDNESS (MG/L) 228

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	7.2	0.06
CHROMIUM	11425.0	
COPPER	48.1	
LEAD	470.4	26.5
NICKEL	3450.3	178.8
ZINC	636.7	
SILVER	16.7	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

LONG ISLAND, NEW YORK - HUNTINGTON, N.Y.	DATE: 5/11/81	HARDNESS (MG/L)	31
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	0.9	0.01	
CHROMIUM	1339.3		
COPPER	7.4		
LEAD	41.8	0.3	
NICKEL	763.4	39.6	
ZINC	122.6		
SILVER	0.6		

LONG ISLAND, NEW YORK - HUNTINGTON, N.Y.	DATE: 5/11/81	HARDNESS (MG/L)	28
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	0.8	0.01	
CHROMIUM	1202.3		
COPPER	6.8		
LEAD	37.0	0.2	
NICKEL	707.5	36.7	
ZINC	112.8		
SILVER	0.5		

LONG ISLAND N.Y. - HUNTINGTON, N.Y.	DATE: 5/11/81	HARDNESS (MG/L)	27
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	0.8	0.01	
CHROMIUM	1137.3		
COPPER	6.5		
LEAD	34.7	0.2	
NICKEL	680.4	35.3	
ZINC	108.1		
SILVER	0.4		

LONG ISLAND N.Y. - HUNTINGTON N.Y.	DATE: 5/11/81	HARDNESS (MG/L)	34
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	1.0	0.01	
CHROMIUM	1481.9		
COPPER	8.1		
LEAD	46.8	0.3	
NICKEL	819.7	42.5	
ZINC	132.5		
SILVER	0.6		

LONG ISLAND N.Y. - HUNTINGTON N.Y.	DATE: 5/11/81	HARDNESS (MG/L)	14
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	0.4	0.00	
CHROMIUM	581.3		
COPPER	3.6		
LEAD	16.3	0.0	
NICKEL	424.3	22.0	
ZINC	64.5		
SILVER	0.1		

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

AUSTIN TX - ROLLINGWOOD SITE	DATE: 5/1/81	HARDNESS (MG/L)	72
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	2.1	0.02	
CHROMIUM	3266.5		
COPPER	16.2		
LEAD	114.3	1.7	
NICKEL	1429.5	74.1	
ZINC	243.2		
SILVER	2.3		

AUSTIN TX - WOODHOLLOW DAM	DATE: 5/1/81	HARDNESS (MG/L)	82
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	2.4	0.02	
CHROMIUM	3771.6		
COPPER	18.3		
LEAD	134.5	2.4	
NICKEL	1581.7	82.0	
ZINC	271.6		
SILVER	2.9		

AUSTIN TX - ROLLINGWOOD SITE	DATE: 5/16/81	HARDNESS (MG/L)	203
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	6.4	0.05	
CHROMIUM	10082.4		
COPPER	43.1		
LEAD	408.5	20.2	
NICKEL	3159.7	163.7	
ZINC	578.4		
SILVER	13.7		

RAPID CITY S.D. 57701 - STATION 5	DATE: 5/16/81	HARDNESS (MG/L)	241
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	7.6	0.06	
CHROMIUM	12147.4		
COPPER	50.7		
LEAD	504.2	30.3	
NICKEL	3602.4	186.7	
ZINC	667.4		
SILVER	18.5		

RAPID CITY S.D. 57701 - STATION 6	DATE: 5/16/81	HARDNESS (MG/L)	220
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	6.9	0.06	
CHROMIUM	10974.2		
COPPER	46.5		
LEAD	449.5	24.3	
NICKEL	3353.9	173.8	
ZINC	617.3		
SILVER	15.7		

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

AUSTIN TX - HART LANE SITE

DATE: 5/23/81

HARDNESS (MG/L) 456

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	14.9	0.12
CHROMIUM	24162.6	
COPPER	92.3	
LEAD	1096.3	135.4
NICKEL	5844.7	302.9
ZINC	1132.2	
SILVER	55.2	

AUSTIN TX - ROLLINGWOOD

DATE: 5/24/81

HARDNESS (MG/L) 99

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.0	0.02
CHROMIUM	4644.3	
COPPER	22.0	
LEAD	170.2	3.7
NICKEL	1831.3	94.9
ZINC	318.8	
SILVER	4.0	

CHICAGO, IL. - LAKE ELLYN OUTLET

DATE: 5/29/81

HARDNESS (MG/L) 171

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	5.3	0.04
CHROMIUM	8356.2	
COPPER	36.6	
LEAD	330.4	13.4
NICKEL	2768.6	143.5
ZINC	500.6	
SILVER	10.2	

CHICAGO, IL. - LAKE ELLYN OUTLET

DATE: 5/29/81

HARDNESS (MG/L) 174

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	5.4	0.04
CHROMIUM	8549.4	
COPPER	37.4	
LEAD	339.0	14.1
NICKEL	2813.5	145.8
ZINC	509.5	
SILVER	10.6	

CHICAGO, IL. - LAKE ELLYN INLET

DATE: 5/29/81

HARDNESS (MG/L) 136

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	4.2	0.03
CHROMIUM	6553.0	
COPPER	29.7	
LEAD	251.1	7.9
NICKEL	2333.3	120.9
ZINC	415.3	
SILVER	6.9	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

CHICAGO,IL. - LAKE ELLYN INLET | DATE: 5/29/81 | HARDNESS (MG/L) 138

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	4.2	0.03
CHROMIUM	6639.2	
COPPER	30.0	
LEAD	254.8	8.1
NICKEL	2354.8	122.0
ZINC	419.5	
SILVER	7.1	

WASH. D.C. MET. AREA - BURKE POND/SEWER PIP | DATE: 6/1/81 | HARDNESS (MG/L) 44

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.3	0.01
CHROMIUM	1943.9	
COPPER	10.3	
LEAD	63.6	0.6
NICKEL	992.1	51.4
ZINC	163.2	
SILVER	1.0	

WASH. DC MET. AREA - BURKE POND/AMB. RESE | DATE: 5/1/81 | HARDNESS (MG/L) 20

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.6	0.00
CHROMIUM	823.3	
COPPER	4.9	
LEAD	24.1	0.1
NICKEL	542.0	28.1
ZINC	84.3	
SILVER	0.3	

WASH. DC MET. AREA - STEDWICK/SEWER PIPE | DATE: 5/1/81 | HARDNESS (MG/L) 17

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.5	0.00
CHROMIUM	681.7	
COPPER	4.1	
LEAD	19.5	0.1
NICKEL	474.6	24.6
ZINC	73.0	
SILVER	0.2	

WASH. DC MET. AREA - STEDWICK/AMB. RESERV | DATE: 6/1/81 | HARDNESS (MG/L) 28

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.8	0.01
CHROMIUM	1202.2	
COPPER	6.8	
LEAD	37.0	0.2
NICKEL	707.5	36.7
ZINC	112.8	
SILVER	0.5	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

WASH. DC MET. AREA - WESTLEIGH/SEWER PIPE — DATE: 6/3/81 — HARDNESS (MG/L) 22

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.6	0.01
CHROMIUM	901.9	
COPPER	5.3	
LEAD	26.7	0.1
NICKEL	577.9	29.9
ZINC	90.5	
SILVER	0.3	

WASH. DC MET. AREA - WESTLEIGH/AMB. RESER — DATE: 5/1/81 — HARDNESS (MG/L) 27

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.8	0.01
CHROMIUM	1135.8	
COPPER	6.5	
LEAD	34.7	0.2
NICKEL	679.8	35.2
ZINC	108.0	
SILVER	0.4	

WASH. DC MET. AREA - BURKE TOWN PLAZA/AMB — DATE: 5/1/81 — HARDNESS (MG/L) 30

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.9	0.01
CHROMIUM	1286.3	
COPPER	7.2	
LEAD	39.9	0.2
NICKEL	741.9	38.4
ZINC	118.8	
SILVER	0.5	

WASH. DC MET. AREA - ROCKVILLE/AMB. RESER — DATE: 5/1/81 — HARDNESS (MG/L) 116

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.5	0.03
CHROMIUM	5527.6	
COPPER	25.6	
LEAD	207.2	5.5
NICKEL	2070.0	107.3
ZINC	364.4	
SILVER	5.3	

RAPID CITY, S.D. - STATION 1 — DATE: 5/17/81 — HARDNESS (MG/L) 143

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	4.4	0.04
CHROMIUM	6896.9	
COPPER	31.0	
LEAD	266.0	8.9
NICKEL	2418.8	125.3
ZINC	432.0	
SILVER	7.5	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

RAPID CITY, SD - STATION 3	DATE: 5/17/81	HARDNESS (MG/L)	249
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	7.9	0.06	
CHROMIUM	12570.8		
COPPER	52.3		
LEAD	524.1	32.7	
NICKEL	3690.3	191.2	
ZINC	685.2		
SILVER	19.5		

BELLEVUE, WA - SURREY DOWNS	DATE: 5/7/81	HARDNESS (MG/L)	13
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	0.4	0.00	
CHROMIUM	519.4		
COPPER	3.3		
LEAD	14.3	0.0	
NICKEL	392.0	20.3	
ZINC	59.2		
SILVER	0.1		

BELLEVUE, WA - LAKE HILLS	DATE: 5/7/81	HARDNESS (MG/L)	11
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	0.3	0.00	
CHROMIUM	441.5		
COPPER	2.8		
LEAD	11.9	0.0	
NICKEL	349.6	18.1	
ZINC	52.3		
SILVER	0.1		

DENVER - ASBURY PK STORM DRAI	DATE: 5/28/81	HARDNESS (MG/L)	153
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	4.7	0.04	
CHROMIUM	7446.0		
COPPER	33.1		
LEAD	290.0	10.5	
NICKEL	2552.8	132.3	
ZINC	458.2		
SILVER	8.5		

DENVER - BIG DRY CR TRIB, EAS	DATE: 5/26/81	HARDNESS (MG/L)	61
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	1.8	0.01	
CHROMIUM	2735.7		
COPPER	13.9		
LEAD	93.6	1.2	
NICKEL	1261.8	65.4	
ZINC	212.2		
SILVER	1.7		

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

DENVER - CHERRY KNOLLS STORM   DATE: 5/28/81   HARDNESS (MG/L) 47

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.4	0.01
CHROMIUM	2092.1	
COPPER	11.0	
LEAD	69.1	0.7
NICKEL	1044.8	54.1
ZINC	172.7	
SILVER	1.1	

DENVER - VILLA ITALIA STORM D   DATE: 5/28/81   HARDNESS (MG/L) 21

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.6	0.00
CHROMIUM	877.9	
COPPER	5.2	
LEAD	25.9	0.1
NICKEL	567.1	29.4
ZINC	88.6	
SILVER	0.3	

DENVER - N. AVE. STORM DRAIN   DATE: 5/28/81   HARDNESS (MG/L) 104

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.1	0.03
CHROMIUM	4887.6	
COPPER	23.0	
LEAD	180.3	4.2
NICKEL	1898.3	98.4
ZINC	331.5	
SILVER	4.3	

DENVER - STORM DRAIN, 116 & C   DATE: 6/2/81   HARDNESS (MG/L) 181

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	5.6	0.05
CHROMIUM	8903.0	
COPPER	38.7	
LEAD	354.9	15.4
NICKEL	2894.9	150.0
ZINC	525.6	
SILVER	11.3	

CHAMPAIGN, ILL - CORN OF WHITE & MATT   DATE: 6/8/81   HARDNESS (MG/L) 230

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	7.3	0.06
CHROMIUM	11553.8	
COPPER	48.6	
LEAD	476.4	27.2
NICKEL	3477.6	180.2
ZINC	642.2	
SILVER	17.0	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

CHAMPAIGN, ILL - CORN OF SHERIDAN & M	DATE: 6/8/81	HARDNESS (MG/L)	157
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	4.9	0.04	
CHROMIUM	7637.7		
COPPER	33.9		
LEAD	298.5	11.0	
NICKEL	2598.8	134.7	
ZINC	467.2		
SILVER	8.8		

CHAMPAIGN, ILL - CORN OF JAMES & DANI	DATE: 6/8/81	HARDNESS (MG/L)	57
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	1.7	0.01	
CHROMIUM	2570.9		
COPPER	13.1		
LEAD	87.2	1.0	
NICKEL	1207.8	62.6	
ZINC	202.3		
SILVER	1.6		

CHAMPAIGN, ILL - CORN OF JOHN & HIGHL	DATE: 6/8/81	HARDNESS (MG/L)	106
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	3.2	0.03	
CHROMIUM	4995.4		
COPPER	23.4		
LEAD	184.8	4.4	
NICKEL	1927.6	99.9	
ZINC	337.1		
SILVER	4.5		

CHAMPAIGN, ILL - CORN OF JOHN & HIGHL	DATE: 6/8/81	HARDNESS (MG/L)	261
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	8.3	0.07	
CHROMIUM	13233.5		
COPPER	54.7		
LEAD	555.4	36.5	
NICKEL	3826.2	198.3	
ZINC	712.8		
SILVER	21.2		

CHAMPAIGN, ILL - CORN SHERIDAN & MATT	DATE: 6/12/81	HARDNESS (MG/L)	129
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	3.9	0.03	
CHROMIUM	6158.5		
COPPER	28.1		
LEAD	234.1	6.9	
NICKEL	2233.5	115.7	
ZINC	396.0		
SILVER	6.3		

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

CHAMPAIGN IL - CORN SHERIDAN & MATT DATE: 6/12/81 HARDNESS (MG/L) 326

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	10.4	0.09
CHROMIUM	16802.3	
COPPER	67.3	
LEAD	727.3	61.4
NICKEL	4526.2	234.5
ZINC	856.4	
SILVER	31.0	

CHAMPAIGN IL - CORN SHERIDAN & MATT DATE: 6/12/81 HARDNESS (MG/L) 123

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.7	0.03
CHROMIUM	5849.6	
COPPER	26.9	
LEAD	220.8	6.2
NICKEL	2154.1	111.6
ZINC	380.6	
SILVER	5.8	

ROCHESTER, NY - THOMAS CR AT BAIRD R DATE: 6/21/81 HARDNESS (MG/L) 383

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	12.4	0.10
CHROMIUM	20020.0	
COPPER	78.4	
LEAD	886.5	89.9
NICKEL	5120.1	265.3
ZINC	979.8	
SILVER	40.9	

ROCHESTER, NY - THOMAS CR AT BAIRD R DATE: 6/21/81 HARDNESS (MG/L) 203

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	6.3	0.05
CHROMIUM	10055.1	
COPPER	43.0	
LEAD	407.2	20.1
NICKEL	3153.7	163.4
ZINC	577.1	
SILVER	13.7	

ROCHESTER, NY - IRONDEQUOIT CR DATE: 6/21/81 HARDNESS (MG/L) 130

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	4.0	0.03
CHROMIUM	6243.1	
COPPER	28.4	
LEAD	237.7	7.1
NICKEL	2255.1	116.9
ZINC	400.1	
SILVER	6.4	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

ROCHESTER, NY - IRONDEQUOIT CR DATE: 6/21/81 HARDNESS (MG/L) 30

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.8	0.01
CHROMIUM	1255.8	
COPPER	7.0	
LEAD	38.8	0.2
NICKEL	729.5	37.8
ZINC	116.7	
SILVER	0.5	

ROCHESTER, NY - WHITEBROOK AT SOUTHG DATE: 6/21/81 HARDNESS (MG/L) 116

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.5	0.03
CHROMIUM	5513.0	
COPPER	25.5	
LEAD	206.5	5.4
NICKEL	2066.1	107.1
ZINC	363.7	
SILVER	5.2	

ROCHESTER, NY - WHITEBROOK AT SOUTHG DATE: 6/21/81 HARDNESS (MG/L) 77

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	2.3	0.02
CHROMIUM	3517.6	
COPPER	17.3	
LEAD	124.3	2.0
NICKEL	1506.0	78.0
ZINC	257.5	
SILVER	2.6	

ROCHESTER, NY - STORM SEWER/E ROCHES DATE: 6/21/81 HARDNESS (MG/L) 100

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.0	0.02
CHROMIUM	4677.0	
COPPER	22.1	
LEAD	171.5	3.8
NICKEL	1840.3	95.4
ZINC	320.5	
SILVER	4.0	

ROCHESTER, NY - STORM SEWER/E ROCHES DATE: 6/21/81 HARDNESS (MG/L) 36

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.0	0.01
CHROMIUM	1544.6	
COPPER	8.4	
LEAD	49.1	0.3
NICKEL	843.9	43.7
ZINC	136.8	
SILVER	0.7	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

LAKE GEORGE, N.Y. - GAGE HOUSE NEAR OUTF — DATE: 5/12/81 — HARDNESS (MG/L) 372

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	12.0	0.10
CHROMIUM	19366.3	
COPPER	76.2	
LEAD	853.9	83.7
NICKEL	5001.9	259.2
ZINC	955.1	
SILVER	38.8	

LAKE GEORGE N.Y. - GAGE HOUSE NEAR OUTF — DATE: 5/12/81 — HARDNESS (MG/L) 135

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	4.1	0.03
CHROMIUM	6467.5	
COPPER	29.3	
LEAD	247.4	7.7
NICKEL	2311.8	119.8
ZINC	411.2	
SILVER	6.8	

LAKE GEORGE N.Y. - GAGE HOUSE NEAR OUTF — DATE: 4/14/81 — HARDNESS (MG/L) 46

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.3	0.01
CHROMIUM	2025.9	
COPPER	10.7	
LEAD	66.7	0.6
NICKEL	1021.4	52.9
ZINC	168.5	
SILVER	1.1	

LAKE GEORGE N.Y. - GAGE HOUSE NEAR MOUT — DATE: 5/12/81 — HARDNESS (MG/L) 31

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.9	0.01
CHROMIUM	1320.3	
COPPER	7.4	
LEAD	41.1	0.2
NICKEL	755.7	39.2
ZINC	121.2	
SILVER	0.5	

LAKE GEORGE N.Y. - GAGE HOUSE NEAR OUTF — DATE: 4/14/81 — HARDNESS (MG/L) 185

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	5.8	0.05
CHROMIUM	9101.1	
COPPER	39.5	
LEAD	363.9	16.2
NICKEL	2940.1	152.4
ZINC	534.6	
SILVER	11.7	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

LAKE GEORGE N.Y. - GAGE HOUSE NEAR OUTF   DATE: 7/3/81   HARDNESS (MG/L) 144

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	4.4	0.04
CHROMIUM	6980.1	
COPPER	31.3	
LEAD	269.6	9.1
NICKEL	2439.3	126.4
ZINC	436.0	
SILVER	7.6	

LAKE GEORGE N.Y. - GAGE HOUSE NEAR OUTF   DATE: 5/11/81   HARDNESS (MG/L) 57

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.7	0.01
CHROMIUM	2535.7	
COPPER	13.0	
LEAD	85.9	1.0
NICKEL	1196.2	62.0
ZINC	200.2	
SILVER	1.5	

LAKE GEORGE N.Y. - GAGE HOUSE NEAR MOUT   DATE: 4/14/81   HARDNESS (MG/L) 28

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.8	0.01
CHROMIUM	1190.7	
COPPER	6.7	
LEAD	36.6	0.2
NICKEL	702.7	36.4
ZINC	112.0	
SILVER	0.5	

MILWAUKEE WIS. - WOODS HOSPITAL   DATE: 7/20/81   HARDNESS (MG/L) 148

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	4.6	0.04
CHROMIUM	7173.1	
COPPER	32.1	
LEAD	278.1	9.6
NICKEL	2486.6	128.9
ZINC	445.2	
SILVER	8.0	

MILWAUKEE WIS. - CAPITAL COURT P.O.   DATE: 7/20/81   HARDNESS (MG/L) 49

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.4	0.01
CHROMIUM	2191.8	
COPPER	11.4	
LEAD	72.9	0.7
NICKEL	1079.6	55.9
ZINC	179.0	
SILVER	1.2	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

BELLEVUE, WASH. - LAKE HILLS DATE: 7/6/81 HARDNESS (MG/L) 11

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.3	0.00
CHROMIUM	442.9	
COPPER	2.8	
LEAD	12.0	0.0
NICKEL	350.4	18.2
ZINC	52.4	
SILVER	0.1	

BELLEVUE, WASH. - SURREY DOWNS DATE: 7/6/81 HARDNESS (MG/L) 13

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.4	0.00
CHROMIUM	538.5	
COPPER	3.4	
LEAD	14.9	0.0
NICKEL	402.0	20.8
ZINC	60.9	
SILVER	0.1	

BELLEVUE, WASHINGTON - SURREY DOWNS DATE: 8/31/81 HARDNESS (MG/L) 24

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.7	0.01
CHROMIUM	1025.1	
COPPER	5.9	
LEAD	30.9	0.1
NICKEL	632.4	32.8
ZINC	99.8	
SILVER	0.4	

SALT LAKE CITY - 1300 SOUTH-SOUTH CON DATE: 10/29/8 HARDNESS (MG/L) 187

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	5.8	0.05
CHROMIUM	9208.9	
COPPER	39.9	
LEAD	368.7	16.6
NICKEL	2964.5	153.6
ZINC	539.4	
SILVER	11.9	

SALT LAKE CITY - 1300 SOUTH-NORTH CO DATE: 10/29/8 HARDNESS (MG/L) 147

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	4.5	0.04
CHROMIUM	7111.7	
COPPER	31.8	
LEAD	275.4	9.5
NICKEL	2471.6	128.1
ZINC	442.3	
SILVER	7.9	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

SALT LAKE CITY - 800 SOUTH-SOUTH COND   DATE: 10/29/8   HARDNESS (MG/L) 188

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	5.9	0.05
CHROMIUM	9283.6	
COPPER	40.2	
LEAD	372.1	16.9
NICKEL	2981.4	154.5
ZINC	542.8	
SILVER	12.0	

SALT LAKE CITY - 800 SOUTH-MIDDLE   DATE: 10/29/8   HARDNESS (MG/L) 125

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.8	0.03
CHROMIUM	5950.7	
COPPER	27.3	
LEAD	225.2	6.4
NICKEL	2180.2	113.0
ZINC	385.7	
SILVER	5.9	

SALT LAKE CITY - 800 SOUTH-NORTH COND   DATE: 10/29/8   HARDNESS (MG/L) 77

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	2.3	0.02
CHROMIUM	3562.1	
COPPER	17.4	
LEAD	126.1	2.1
NICKEL	1519.4	78.7
ZINC	260.0	
SILVER	2.6	

SALT LAKE CITY - NORTH TEMPLE STORM D   DATE: 10/29/8   HARDNESS (MG/L) 188

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	5.9	0.05
CHROMIUM	9294.7	
COPPER	40.2	
LEAD	372.6	16.9
NICKEL	2983.9	154.6
ZINC	543.3	
SILVER	12.1	

EUGENE, OR - A-3 BERTELSEN RD   DATE: 10/27/8   HARDNESS (MG/L) 100

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.0	0.02
CHROMIUM	4675.1	
COPPER	22.1	
LEAD	171.4	3.8
NICKEL	1839.8	95.3
ZINC	320.4	
SILVER	4.0	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

EUGENE, OR - A-3 BERTELSEN RD — DATE: 10/27/8 — HARDNESS (MG/L) 102

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.1	0.03
CHROMIUM	4788.7	
COPPER	22.6	
LEAD	176.2	4.0
NICKEL	1871.2	97.0
ZINC	326.4	
SILVER	4.2	

EUGENE, OR - POLK ST. STORMSEWER — DATE: 10/27/8 — HARDNESS (MG/L) 29

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.8	0.01
CHROMIUM	1221.1	
COPPER	6.9	
LEAD	37.6	0.2
NICKEL	715.3	37.1
ZINC	114.2	
SILVER	0.5	

DURHAM, NH - 1-PKG — DATE: 7/29/81 — HARDNESS (MG/L) 54

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.6	0.01
CHROMIUM	2399.0	
COPPER	12.4	
LEAD	80.7	0.9
NICKEL	1150.4	59.6
ZINC	191.9	
SILVER	1.4	

DURHAM, NH - 1-PKG — DATE: 7/29/81 — HARDNESS (MG/L) 9

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.2	0.00
CHROMIUM	350.8	
COPPER	2.3	
LEAD	9.2	0.0
NICKEL	297.4	15.4
ZINC	43.8	
SILVER	0.1	

DURHAM, NH - 2-PIE — DATE: 7/29/81 — HARDNESS (MG/L) 32

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.9	0.01
CHROMIUM	1386.1	
COPPER	7.7	
LEAD	43.4	0.3
NICKEL	782.0	40.5
ZINC	125.9	
SILVER	0.6	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

DURHAM, NH - 3-PIE

METAL (CONC. IN UG/L)	DATE: 7/29/81 ACUTE WQC	HARDNESS (MG/L) 42 CHRONIC WQC
CADMIUM	1.2	0.01
CHROMIUM	1852.5	
COPPER	9.9	
LEAD	60.3	0.5
NICKEL	959.1	49.7
ZINC	157.3	
SILVER	0.9	

DURHAM, NH - 5-OYS

METAL (CONC. IN UG/L)	DATE: 7/29/81 ACUTE WQC	HARDNESS (MG/L) 40 CHRONIC WQC
CADMIUM	1.2	0.01
CHROMIUM	1739.2	
COPPER	9.3	
LEAD	56.1	0.4
NICKEL	917.4	47.5
ZINC	149.8	
SILVER	0.8	

DURHAM, NH - 7-OYS

METAL (CONC. IN UG/L)	DATE: 7/29/81 ACUTE WQC	HARDNESS (MG/L) 41 CHRONIC WQC
CADMIUM	1.2	0.01
CHROMIUM	1814.2	
COPPER	9.7	
LEAD	58.8	0.5
NICKEL	945.1	49.0
ZINC	154.8	
SILVER	0.9	

BALTIMORE - STONY RUN 1

METAL (CONC. IN UG/L)	DATE: 10-23-8 ACUTE WQC	HARDNESS (MG/L) 101 CHRONIC WQC
CADMIUM	3.0	0.02
CHROMIUM	4718.8	
COPPER	22.3	
LEAD	173.3	3.9
NICKEL	1851.9	96.0
ZINC	322.7	
SILVER	4.1	

BALTIMORE - LAKE ROLAND 1

METAL (CONC. IN UG/L)	DATE: 10-23-8 ACUTE WQC	HARDNESS (MG/L) 134 CHRONIC WQC
CADMIUM	4.1	0.03
CHROMIUM	6432.2	
COPPER	29.2	
LEAD	245.8	7.6
NICKEL	2302.9	119.3
ZINC	409.4	
SILVER	6.7	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

BALTIMORE, MD - MT. WASHINGTON 1 DATE: 10-23-8 HARDNESS (MG/L) 62

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.8	0.02
CHROMIUM	2803.3	
COPPER	14.2	
LEAD	96.2	1.2
NICKEL	1283.7	66.5
ZINC	216.3	
SILVER	1.8	

BALTIMORE, MD - HAMPDEN 1 DATE: 10-23-8 HARDNESS (MG/L) 51

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.5	0.01
CHROMIUM	2257.9	
COPPER	11.7	
LEAD	75.3	0.8
NICKEL	1102.4	57.1
ZINC	183.1	
SILVER	1.3	

BALTIMORE, MD - HOMELAND 1 DATE: 10-23-8 HARDNESS (MG/L) 58

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.7	0.01
CHROMIUM	2607.4	
COPPER	13.3	
LEAD	88.6	1.1
NICKEL	1219.9	63.2
ZINC	204.5	
SILVER	1.6	

BALTIMORE, MD - BOLTON HILL 1 DATE: 10-23-8 HARDNESS (MG/L) 72

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	2.1	0.02
CHROMIUM	3281.3	
COPPER	16.2	
LEAD	114.9	1.8
NICKEL	1434.1	74.3
ZINC	244.1	
SILVER	2.3	

BALTIMORE, MD -BIDDLE ST. 1 DATE: 10-23-8 HARDNESS (MG/L) 91

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	2.7	0.02
CHROMIUM	4226.6	
COPPER	20.2	
LEAD	153.0	3.0
NICKEL	1713.7	88.8
ZINC	296.5	
SILVER	3.4	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

BALTIMORE - STONY RUN 2 DATE: 10-23-8 HARDNESS (MG/L) 66

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.9	0.02
CHROMIUM	2988.6	
COPPER	15.0	
LEAD	103.4	1.4
NICKEL	1342.9	69.6
ZINC	227.2	
SILVER	2.0	

BALTIMORE - LAKE ROLAND 2 DATE: 10-23-8 HARDNESS (MG/L) 141

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	4.3	0.04
CHROMIUM	6798.6	
COPPER	30.6	
LEAD	261.7	8.6
NICKEL	2394.5	124.1
ZINC	427.2	
SILVER	7.3	

BALTIMORE - MT WASHINGTON 2 DATE: 10-23-8 HARDNESS (MG/L) 58

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.7	0.01
CHROMIUM	2610.7	
COPPER	13.3	
LEAD	88.8	1.1
NICKEL	1221.0	63.3
ZINC	204.8	
SILVER	1.6	

BALTIMORE - HAMPDEN 2 DATE: 10-23-8 HARDNESS (MG/L) 57

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.7	0.01
CHROMIUM	2550.5	
COPPER	13.0	
LEAD	86.5	1.0
NICKEL	1201.1	62.2
ZINC	201.1	
SILVER	1.5	

BALTIMORE - HOMELAND 2 DATE: 10-23-8 HARDNESS (MG/L) 36

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.0	0.01
CHROMIUM	1538.0	
COPPER	8.4	
LEAD	48.8	0.3
NICKEL	841.4	43.6
ZINC	136.3	
SILVER	0.7	

Table D-2 (cont.)

Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location

(147 Sites)

BALTIMORE - BOLTON HILL 2	DATE: 10-23-8	HARDNESS (MG/L)	26
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	0.7	0.01	
CHROMIUM	1078.5		
COPPER	6.2		
LEAD	32.7	0.2	
NICKEL	655.5	34.0	
ZINC	103.8		
SILVER	0.4		

FRESNO, CA - MULTIPLE RESIDENTIAL	DATE: 1-4-82	HARDNESS (MG/L)	11
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	0.3	0.00	
CHROMIUM	433.9		
COPPER	2.8		
LEAD	11.7	0.0	
NICKEL	345.3	17.9	
ZINC	51.6		
SILVER	0.1		

FRESNO, CA - COMMERCIAL	DATE: 1-4-82	HARDNESS (MG/L)	9
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	0.2	0.00	
CHROMIUM	336.2		
COPPER	2.2		
LEAD	8.8	0.0	
NICKEL	288.6	15.0	
ZINC	42.4		
SILVER	0.1		

FRESNO - MULTIPLE RESIDENTIAL	DATE: 1-4-82	HARDNESS (MG/L)	16
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	0.4	0.00	
CHROMIUM	644.4		
COPPER	3.9		
LEAD	18.3	0.1	
NICKEL	456.2	23.6	
ZINC	69.9		
SILVER	0.2		

FRESNO - SINGLE RESIDENTIAL	DATE: 1-4-82	HARDNESS (MG/L)	7
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	0.2	0.00	
CHROMIUM	264.3		
COPPER	1.8		
LEAD	6.7	0.0	
NICKEL	243.6	12.6	
ZINC	35.2		
SILVER	0.0		

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

FRESNO, CA - INDUSTRIAL
DATE: 1-4-82
HARDNESS (MG/L) 64

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.9	0.02
CHROMIUM	2881.9	
COPPER	14.5	
LEAD	99.3	1.3
NICKEL	1308.9	67.8
ZINC	220.9	
SILVER	1.9	

LANSING, MI - BMP OUTLET
DATE:
HARDNESS (MG/L) 180

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	5.6	0.05
CHROMIUM	8856.8	
COPPER	38.5	
LEAD	352.8	15.3
NICKEL	2884.3	149.5
ZINC	523.5	
SILVER	11.2	

FRESNO - INDUSTRIAL
DATE: 1-4-82
HARDNESS (MG/L) 59

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.7	0.01
CHROMIUM	2669.4	
COPPER	13.6	
LEAD	91.0	1.1
NICKEL	1240.2	64.3
ZINC	208.3	
SILVER	1.7	

FRESNO - SINGLE RESIDENTIAL
DATE: 1-4-82
HARDNESS (MG/L) 7

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.2	0.00
CHROMIUM	278.7	
COPPER	1.9	
LEAD	7.1	0.0
NICKEL	252.9	13.1
ZINC	36.7	
SILVER	0.0	

FRESNO - COMMERCIAL
DATE: 1-4-82
HARDNESS (MG/L) 6

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.1	0.00
CHROMIUM	207.0	
COPPER	1.5	
LEAD	5.1	0.0
NICKEL	205.2	10.6
ZINC	29.2	
SILVER	0.0	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

LANSING MI. - BMP OUTLET	DATE:	HARDNESS (MG/L)	177
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	5.5	0.05	
CHROMIUM	8689.1		
COPPER	37.9		
LEAD	345.3	14.6	
NICKEL	2845.7	147.5	
ZINC	515.9		
SILVER	10.8		

LANSING MI. - BMP OUTLET	DATE: 11-19-8	HARDNESS (MG/L)	152
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	4.7	0.04	
CHROMIUM	7395.2		
COPPER	32.9		
LEAD	287.8	10.3	
NICKEL	2540.5	131.6	
ZINC	455.8		
SILVER	8.4		

LANSING MI. - BMP OUTLET	DATE: 11-19-8	HARDNESS (MG/L)	85
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	2.5	0.02	
CHROMIUM	3941.0		
COPPER	19.1		
LEAD	141.4	2.6	
NICKEL	1631.4	84.5	
ZINC	281.0		
SILVER	3.1		

LANSING MI. - STUDY AREA OUTLET	DATE: 11-19-8	HARDNESS (MG/L)	140
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	4.3	0.04	
CHROMIUM	6760.0		
COPPER	30.5		
LEAD	260.0	8.5	
NICKEL	2384.9	123.6	
ZINC	425.4		
SILVER	7.3		

LANSING MI. - BMP OUTLET	DATE: 11-19-8	HARDNESS (MG/L)	118
METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC	
CADMIUM	3.6	0.03	
CHROMIUM	5611.0		
COPPER	25.9		
LEAD	210.7	5.6	
NICKEL	2091.9	108.4	
ZINC	368.6		
SILVER	5.4		

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

LANSING MI. - BMP OUTLET — DATE: 11-19-8 — HARDNESS (MG/L) 108

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.3	0.03
CHROMIUM	5097.3	
COPPER	23.8	
LEAD	189.0	4.6
NICKEL	1955.2	101.3
ZINC	342.4	
SILVER	4.6	

LANSING MI. - BMP INLET — DATE: 11-19-8 — HARDNESS (MG/L) 105

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.2	0.03
CHROMIUM	4933.5	
COPPER	23.2	
LEAD	182.2	4.3
NICKEL	1910.8	99.0
ZINC	333.9	
SILVER	4.4	

LITTLE ROCK - ROCK CR @ WEST MARLC — DATE: 1-22-82 — HARDNESS (MG/L) 18

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.5	0.00
CHROMIUM	755.2	
COPPER	4.5	
LEAD	21.9	0.1
NICKEL	510.1	26.4
ZINC	78.9	
SILVER	0.2	

LITTLE ROCK - ROCK CR @ SHACKLEFOR — DATE: 1-22-82 — HARDNESS (MG/L) 19

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.5	0.00
CHROMIUM	800.1	
COPPER	4.8	
LEAD	23.3	0.1
NICKEL	531.2	27.5
ZINC	82.5	
SILVER	0.2	

LITTLE ROCK - ROCK CR @ I-630 — DATE: 1-22-82 — HARDNESS (MG/L) 32

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.9	0.01
CHROMIUM	1360.4	
COPPER	7.5	
LEAD	42.5	0.3
NICKEL	771.8	40.0
ZINC	124.1	
SILVER	0.6	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

LITTLE ROCK - ROCK CR @ BOYLE PK

DATE: 1-22-82

HARDNESS (MG/L) 25

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.7	0.01
CHROMIUM	1047.1	
COPPER	6.0	
LEAD	31.6	0.1
NICKEL	642.0	33.3
ZINC	101.5	
SILVER	0.4	

LITTLE ROCK - ROCK CR @ 36TH

DATE: 1-22-82

HARDNESS (MG/L) 25

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.7	0.01
CHROMIUM	1040.4	
COPPER	6.0	
LEAD	31.4	0.1
NICKEL	639.0	33.1
ZINC	101.0	
SILVER	0.4	

LITTLE ROCK - FOUCHE CR @ HWY 5

DATE: 1-22-82

HARDNESS (MG/L) 45

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.3	0.01
CHROMIUM	1962.2	
COPPER	10.4	
LEAD	64.3	0.6
NICKEL	998.7	51.8
ZINC	164.4	
SILVER	1.0	

LITTLE ROCK - FOUCHE CR @ UNIV.

DATE: 1-22-82

HARDNESS (MG/L) 27

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.8	0.01
CHROMIUM	1154.7	
COPPER	6.5	
LEAD	35.3	0.2
NICKEL	687.7	35.6
ZINC	109.4	
SILVER	0.4	

LITTLE ROCK - FOUCHE CR @ LINDSEY

DATE: 1-22-82

HARDNESS (MG/L) 41

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	1.2	0.01
CHROMIUM	1791.5	
COPPER	9.6	
LEAD	58.0	0.5
NICKEL	936.7	48.5
ZINC	153.3	
SILVER	0.9	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

WINSTON-SALEM, NC - BURKE BRANCH DATE: 4-27-82 HARDNESS (MG/L) 33

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.9	0.01
CHROMIUM	1424.5	
COPPER	7.9	
LEAD	44.8	0.3
NICKEL	797.2	41.3
ZINC	128.5	
SILVER	0.6	

WINSTON-SALEM, NC - BURKE BRANCH DATE: 4-27-82 HARDNESS (MG/L) 29

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.8	0.01
CHROMIUM	1223.7	
COPPER	6.9	
LEAD	37.7	0.2
NICKEL	716.4	37.1
ZINC	114.4	
SILVER	0.5	

WINSTON-SALEM, NC - BURKE BRANCH DATE: 4-27-82 HARDNESS (MG/L) 26

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.7	0.01
CHROMIUM	1102.2	
COPPER	6.3	
LEAD	33.5	0.2
NICKEL	665.5	34.5
ZINC	105.5	
SILVER	0.4	

WINSTON-SALEM, NC - BURKE BRANCH DATE: 4-27-82 HARDNESS (MG/L) 73

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	2.2	0.02
CHROMIUM	3320.5	
COPPER	16.4	
LEAD	116.5	1.8
NICKEL	1446.1	74.9
ZINC	246.3	
SILVER	2.3	

WINSTON-SALEM, NC - BURKE BRANCH DATE: 4-27-82 HARDNESS (MG/L) 26

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.7	0.01
CHROMIUM	1102.2	
COPPER	6.3	
LEAD	33.5	0.2
NICKEL	665.5	34.5
ZINC	105.5	
SILVER	0.4	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

WINSTON-SALEM, NC - BURKE BRANCH DATE: 4-27-82 HARDNESS (MG/L) 18

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.5	0.00
CHROMIUM	719.2	
COPPER	4.3	
LEAD	20.7	0.1
NICKEL	492.8	25.5
ZINC	76.0	
SILVER	0.2	

WINSTON-SALEM, NC - BURKE BRANCH DATE: 4-27-82 HARDNESS (MG/L) 17

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.5	0.00
CHROMIUM	679.1	
COPPER	4.1	
LEAD	19.4	0.1
NICKEL	473.3	24.5
ZINC	72.7	
SILVER	0.2	

WINSTON-SALEM, NC - BURKE BRANCH DATE: 4-27-82 HARDNESS (MG/L) 20

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	0.6	0.00
CHROMIUM	841.1	
COPPER	5.0	
LEAD	24.7	0.1
NICKEL	550.3	28.5
ZINC	85.7	
SILVER	0.3	

RAPID CITY,SD - STATION 1 DATE: 5/10/82 HARDNESS (MG/L) 196

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	6.1	0.05
CHROMIUM	9694.4	
COPPER	41.7	
LEAD	390.8	18.6
NICKEL	3073.6	159.3
ZINC	561.2	
SILVER	12.9	

RAPID CITY,SD - STATION 3 DATE: 5/10/82 HARDNESS (MG/L) 326

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	10.5	0.09
CHROMIUM	16826.6	
COPPER	67.4	
LEAD	728.5	61.6
NICKEL	4530.8	234.8
ZINC	857.3	
SILVER	31.0	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

RAPID CITY, SD - STATION 5 DATE: 5/10/82 HARDNESS (MG/L) 434

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	14.1	0.12
CHROMIUM	22883.9	
COPPER	88.1	
LEAD	1031.0	120.3
NICKEL	5625.3	291.5
ZINC	1085.8	
SILVER	50.6	

RAPID CITY, SD - STATION 6 DATE: 5/10/82 HARDNESS (MG/L) 699

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	23.3	0.19
CHROMIUM	38313.2	
COPPER	137.9	
LEAD	1845.5	369.3
NICKEL	8084.3	418.9
ZINC	1613.5	
SILVER	115.0	

MILWAUKEE, WI - WOODS DATE: 5/11/82 HARDNESS (MG/L) 267

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	8.5	0.07
CHROMIUM	13534.7	
COPPER	55.8	
LEAD	569.7	38.4
NICKEL	3887.2	201.4
ZINC	725.2	
SILVER	21.9	

MILWAUKEE, WI - LINCOLN CREEK DATE: 5/11/82 HARDNESS (MG/L) 187

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	5.8	0.05
CHROMIUM	9212.3	
COPPER	39.9	
LEAD	368.9	16.6
NICKEL	2965.3	153.7
ZINC	539.6	
SILVER	11.9	

KANSAS CITY, KS - IS1 DATE: 5/5/82 HARDNESS (MG/L) 251

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	8.0	0.07
CHROMIUM	12698.6	
COPPER	52.7	
LEAD	530.1	33.4
NICKEL	3716.7	192.6
ZINC	690.5	
SILVER	19.8	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

KANSAS CITY, KS - IS3 DATE: 5/5/82 HARDNESS (MG/L) 0

KANSAS CITY, KS - IS5 IS5 DATE: 5/5/82 HARDNESS (MG/L) 190

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	5.9	0.05
CHROMIUM	9370.0	
COPPER	40.5	
LEAD	376.0	17.2
NICKEL	3000.9	155.5
ZINC	546.7	
SILVER	12.2	

KANSAS CITY, KS - IC DATE: 5/5/82 HARDNESS (MG/L) 67

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	2.0	0.02
CHROMIUM	3065.1	
COPPER	15.3	
LEAD	106.4	1.5
NICKEL	1366.9	70.8
ZINC	231.6	
SILVER	2.1	

KANSAS CITY, KS - II DATE: 5/5/82 HARDNESS (MG/L) 120

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	3.7	0.03
CHROMIUM	5707.7	
COPPER	26.3	
LEAD	214.8	5.9
NICKEL	2117.2	109.7
ZINC	373.5	
SILVER	5.5	

KANSAS CITY, KS - RS1 DATE: 5/5/82 HARDNESS (MG/L) 442

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	14.4	0.12
CHROMIUM	23373.0	
COPPER	89.7	
LEAD	1056.0	126.0
NICKEL	5709.6	295.9
ZINC	1103.6	
SILVER	52.4	

KANSAS CITY, KS - RS3 DATE: 5/5/82 HARDNESS (MG/L) 390

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	12.6	0.10
CHROMIUM	20420.1	
COPPER	79.8	
LEAD	906.5	93.9
NICKEL	5191.9	269.0
ZINC	994.8	
SILVER	42.2	

Table D-2 (cont.)
Calculated Water Quality Criteria for Selected Toxic Metals, by Sample Location
(147 Sites)

KANSAS CITY, KS - RR DATE: 5/5/82 HARDNESS (MG/L) 287

METAL (CONC. IN UG/L)	ACUTE WQC	CHRONIC WQC
CADMIUM	9.1	0.08
CHROMIUM	14624.7	
COPPER	59.6	
LEAD	621.8	45.4
NICKEL	4105.0	212.7
ZINC	769.7	
SILVER	24.8	

NOTE: HARDNESS CALCULATED USING MEASURED CONCENTRATIONS OF CALCIUM, MAGNESIUM AND STRONTIUM.

Appendix E - Special Metals Quality Control Data

DISCUSSION

Field samples have been analyzed in a batch mode in conjunction with specific types of internally and externally prepared control samples. Control samples are those samples introduced into the train of actual field samples as a monitor of the performance of the analytical procedure and a measure of the quality of the data generated.

Five types of control samples have been prepared and analyzed with the NURP Special Metals field samples:

Blanks - consist of laboratory pure water treated in a manner identical to that of an actual field sample. Blanks provide information concerning contamination and other positive interferences introduced within the laboratory. The blank value is reported in concentration units in the same fashion as a field sample.

Duplicates - duplicate samples are generated by splitting a field sample in to two aliquots. Both aliquots are then prepared and analyzed independently to provide an indication of the precision of the analysis. This measure of precision will include any variability introduced by the sample splitting process. Results of the comparison of this data are reported as relative.

Spikes - spiked samples are generated by adding known amounts of an analyte (i.e., pollutant being measured) to an aliquot of a field sample. The spiked and unspiked sample are then prepared and analyzed to provide information on matrix effects (effects of constituents other than the analyte contained in the sample) and accuracy. Percent spike recovery is calculated as follows:

$$\text{Percent Spike Recovery:} \quad \frac{Xs - X}{S} \times 100$$

Where Xs: observed concentration of spiked sample,

X: observed concentration of unspiked sample, and

S: true spike concentration

Method
Standard - a method standard is a spiked pure water sample prepared in the laboratory. Accuracy of the analytical method is evaluated using this control sample in the absence of sample matrix interference. Percent recovery for the method standard is calculated in the same manner presented for spikes.

Reference
Standard - a reference standard is an externally prepared material analyzed along with the sample batch. Accuracy of the analytical data can then be evaluated against a verified material with a similar sample matrix. EPA spiked water reference standards used in this program roughly simulate urban runoff samples and therefore provide a suitable reference standard in a similar sample matrix. Percent recovery for the reference standard is calculated in the same manner presented for spikes.

Table E-1 gives the final quality control summary data for this project. Recoveries for spiked samples, method standards, and reference standards are within 90 to 110 percent for most metals and relative standard deviations for duplicate samples are generally less than 10 percent. QC results for several non-priority pollutant metals do, however, suggest possible problem areas. These include possible contamination (boron) problems as a result of the field filtration apparatus, and apparent difficulties in preparing equivalent subsamples for duplicate analysis which resulted in poor precision for the analysis of iron and aluminum.

An external quality assurance audit of the contract laboratory was conducted by EPA. The performance evaluation report is given as Exhibit E-1. All the metals reported for this analysis were found acceptable.

Table E-1

NURP SPECIAL METALS PROJECT:
QUALITY CONTROL SUMMARY DATA (147 SAMPLES)

ELEMENT	PHASE	AVERAGE BLANK CONCENTRATION (mg/l)	AVERAGE DUPLICATE RPD[1] (%)	AVERAGE SPIKE RECOVERY[2] (%)	AVERAGE METHOD STANDARD RECOVERY[3] (%)	AVERAGE REFERENCE STANDARD RECOVERY[3] (%)
Aluminum	Total	< 0.05 (n=16)[4]	15. (n=10)	93. (n=6)[6]	90. (n=10)	106. (n=24)
	Total Recoverable	< 0.05 (n=16)	8. (n=10)	91. (n=7)[6]	97. (n=10)	104. (n=22)
	Dissolved	NA[5]	0. (n=3)[8]	110. (n=4)	NA	106. (n=23)
Arsenic	Total	< 0.01 (n=14)	20. (n=2)[8]	104. (n=7)	99. (n=8)	118. (n=30)
	Total Recoverable	< 0.01 (n=16)	NR[7]	100. (n=10)	99. (n=10)	111. (n=32)
	Dissolved	NA	NR	96. (n=5)	NA	121. (n=30)
Barium	Total	< 0.01 (n=16)	3. (n=9)[8]	98. (n=10)	98. (n=10)	103. (n=23)
	Total Recoverable	< 0.01 (n=16)	0. (n=8)[8]	94. (n=10)	96. (n=10)	102. (n=22)
	Dissolved	NA	0. (n=4)[8]	99. (n=4)	NA	103. (n=21)
Beryllium	Total	< 0.002 (n=16)	NR	97. (n=10)	97. (n=10)	104. (n=24)
	Total Recoverable	< 0.002 (n=16)	NR	96. (n=10)	97. (n=10)	103. (n=22)
	Dissolved	NA	NR	99. (n=4)	NA	104. (n=22)
Boron	Total	< 0.01 (n=16)	20. (n=7)[8]	88. (n=10)	96. (n=9)	99. (n=22)
	Total Recoverable	0.02 (n=16)	25. (n=6)[8]	93. (n=10)	118. (n=10)	99. (n=16)
	Dissolved	NA	7. (n=4)[8]	99. (n=4)	NA	99. (n=18)
Cadmium	Total	< 0.005 (n=16)	NR	96. (n=10)	96. (n=10)	97. (n=24)
	Total Recoverable	< 0.005 (n=16)	NR	95. (n=10)	97. (n=10)	99. (n=22)
	Dissolved	NA	NR	102. (n=4)	NA	100. (n=23)

Date Prepared: August 12, 1982

Table E-1 (Cont.)

NURP SPECIAL METALS PROJECT:
QUALITY CONTROL SUMMARY DATA (147 SAMPLES)

ELEMENT	PHASE	AVERAGE BLANK CONCENTRATION (mg/1)	AVERAGE DUPLICATE RPD^{1} (%)	AVERAGE SPIKE RECOVERY^{2} (%)	AVERAGE METHOD STANDARD RECOVERY^{3} (%)	AVERAGE REFERENCE STANDARD RECOVERY^{3} (%)
Calcium	Total	< 0.1 (n=16)	4. (n=10)	100. (n=1)^{6}	109. (n=9)	104. (n=24)
	Total Recoverable	0.2 (n=16)	3. (n=10)	-^{6}	140. (n=10)	104. (n=22)
	Dissolved	NA	0. (n=5)	115. (n=2)^{6}	NA	105. (n=22)
Chromium	Total	0.02 (n=16)	0. (n=3)^{8}	97. (n=10)	98. (n=10)	105. (n=24)
	Total Recoverable	< 0.01 (n=16)	0. (n=2)^{8}	95. (n=10)	101. (n=10)	101. (n=22)
	Dissolved	NA	NR	100. (n=4)	NA	100. (n=24)
Cobalt	Total	< 0.01 (n=16)	NR	97. (n=10)	97. (n=10)	103. (n=24)
	Total Recoverable	< 0.01 (n=16)	NR	93. (n=10)	97. (n=10)	102. (n=22)
	Dissolved	NA	NR	101. (n=4)	NA	101. (n=23)
Copper	Total	< 0.02 (n=16)	0. (n=4)^{8}	98. (n=10)	94. (n=10)	109. (n=24)
	Total Recoverable	< 0.02 (n=16)	0. (n=7)^{8}	96. (n=10)	96. (n=10)	107. (n=22)
	Dissolved	NA	0. (n=2)^{8}	98. (n=4)	NA	108. (n=23)
Iron	Total	0.03 (n=16)	10. (n=10)	105. (n=5)^{6}	98. (n=10)	107. (n=24)
	Total Recoverable	< 0.02 (n=16)	6. (n=10)	97. (n=7)^{6}	96. (n=10)	103. (n=24)
	Dissolved	NA	0. (n=4)^{8}	93. (n=4)	NA	103. (n=23)
Lead	Total	< 0.04 (n=16)	18. (n=5)^{8}	96. (n=10)	98. (n=10)	100. (n=24)
	Total Recoverable	< 0.04 (n=16)	8. (n=7)^{8}	93. (n=10)	106. (n=10)	102. (n=22)
	Dissolved	NA	0. (n=1)^{8}	132. (n=4)	NA	100. (n=23)

Date Prepared: August 12, 1982

Table E-1 (Cont.)

NURP SPECIAL METALS PROJECT:
QUALITY CONTROL SUMMARY DATA (147 SAMPLES)

ELEMENT	PHASE	AVERAGE BLANK CONCENTRATION (mg/1)	AVERAGE DUPLICATE RPD^{1} (%)	AVERAGE SPIKE RECOVERY^{2} (%)	AVERAGE METHOD STANDARD RECOVERY^{3} (%)	AVERAGE REFERENCE STANDARD RECOVERY^{3} (%)
Lithium	Total	< 0.01 (n=16)	0. (n=2)^{8}	97. (n=10)	97. (n=10)	99. (n=19)
	Total Recoverable	< 0.01 (n=16)	0. (n=2)^{8}	96. (n=10)	97. (n=10)	99. (n=12)
	Dissolved	NA	NR	100. (n=4)	NA	98. (n=12)
Magnesium	Total	< 0.1 (n=16)	6. (n=10)	125. (n=2)^{6}	100. (n=10)	103. (n=24)
	Total Recoverable	< 0.1 (n=16)	4. (n=10)	92. (n=6)^{6}	100. (n=10)	105. (n=22)
	Dissolved	NA	0. (n=5)	100. (n=2)^{6}	NA	105. (n=22)
Manganese	Total	< 0.01 (n=16)	7. (n=10)	95. (n=10)	97. (n=10)	102. (n=24)
	Total Recoverable	< 0.01 (n=16)	1. (n=10)	96. (n=10)	96. (n=10)	102. (n=22)
	Dissolved	NA	0. (n=3)^{8}	101. (n=4)	NA	101. (n=23)
Mercury	Total/Dissolved	< 0.001 (n=27)	NR	102. (n=18)	NA	95. (n=35)
Molybdenum	Total	< 0.01 (n=16)	NR	97. (n=10)	100. (n=10)	106. (n=19)
	Total Recoverable	< 0.01 (n=16)	0. (n=1)^{8}	93. (n=10)	97. (n=10)	101. (n=12)
	Dissolved	NA	NR	97. (n=4)	NA	104. (n=12)
Nickel	Total	< 0.02 (n=16)	0. (n=1)^{8}	102. (n=10)	100. (n=10)	101. (n=24)
	Total Recoverable	< 0.02 (n=16)	NR	98. (n=10)	97. (n=10)	101. (n=22)
	Dissolved	NA	NR	101. (n=4)	NA	100. (n=23)
Potassium	Total	< 0.2 (n=16)	10. (n=10)	105. (n=10)	107. (n=9)	119. (n=24)
	Total Recoverable	< 0.2 (n=16)	9. (n=10)	101. (n=10)	107. (n=10)	131. (n=22)
	Dissolved	NA	6. (n=5)	99. (n=4)	NA	135. (n=22)

Date Prepared: August 12, 1982

Table E-1 (Cont.)

NURP SPECIAL METALS PROJECT:
QUALITY CONTROL SUMMARY DATA (147 SAMPLES)

ELEMENT	PHASE	AVERAGE BLANK CONCENTRATION (mg/l)	AVERAGE DUPLICATE RPD^1 (%)	AVERAGE SPIKE RECOVERY^2 (%)	AVERAGE METHOD STANDARD RECOVERY^3 (%)	AVERAGE REFERENCE STANDARD RECOVERY^3 (%)
Selenium	Total	< 0.01 (n=20)	NR	92. (n=12)	98. (n=12)	104. (n=36)
	Total Recoverable	< 0.01 (n=16)	NR	91. (n=10)	94. (n=10)	106. (n=28)
	Dissolved	NA	NR	99. (n=5)	NA	101. (n=25)
Silver	Total	< 0.01 (n=16)	NR	94. (n=10)	99. (n=10)	89. (n=11)
	Total Recoverable	< 0.01 (n=16)	NR	95. (n=10)	93. (n=10)	92. (n=19)
	Dissolved	NA	NR	100. (n=4)	NA	91. (n=19)
Sodium	Total	0.1 (n=16)	3. (n=10)	91. (n=9)^6	100. (n=10)	99. (n=25)
	Total Recoverable	0.3 (n=16)	5. (n=10)	101. (n=9)^6	101. (n=10)	101. (n=22)
	Dissolved	NA	1. (n=5)	95. (n=4)	NA	102. (n=22)
Strontium	Total	< 0.01 (n=16)	7. (n=10)	96. (n=10)	98. (n=10)	101. (n=19)
	Total Recoverable	< 0.01 (n=16)	7. (n=10)	101. (n=10)	96. (n=10)	100. (n=12)
	Dissolved	NA	10. (n=4)	99. (n=4)	NA	100. (n=12)
Thallium	Total	< 0.01 (n=19)	NR	96. (n=12)	106. (n=12)	112. (n=30)
	Total Recoverable	< 0.01 (n=15)	NR	100. (n=10)	110. (n=10)	110. (n=28)
	Dissolved	NA	NR	114. (n=5)	NA	109. (n=24)
Tin	Total	< 0.05 (n=16)	NR	97. (n=10)	100. (n=10)	101. (n=14)
	Total Recoverable	< 0.05 (n=16)	NR	92. (n=10)	109. (n=10)	106. (n=8)
	Dissolved	NA	NR	88. (n=4)	NA	101. (n=8)

Date Prepared: August 12, 1982

Table E-1 (Cont.)

NURP SPECIAL METALS PROJECT:
QUALITY CONTROL SUMMARY DATA (147 SAMPLES)

ELEMENT	PHASE	AVERAGE BLANK CONCENTRATION (mg/1)	AVERAGE DUPLICATE RPD[1] (%)	AVERAGE SPIKE RECOVERY[2] (%)	AVERAGE METHOD STANDARD RECOVERY[3] (%)	AVERAGE REFERENCE STANDARD RECOVERY[3] (%)
Titanium	Total	< 0.01 (n=16)	9. (n=8)[8]	84. (n=10)	96. (n=10)	101. (n=14)
	Total Recoverable	< 0.01 (n=16)	9. (n=7)[8]	84. (n=10)	97. (n=10)	100. (n=8)
	Dissolved	NA	NR	99. (n=4)	NA	99. (n=8)
Vanadium	Total	< 0.01 (n=16)	10. (n=4)[8]	97. (n=10)	99. (n=9)	105. (n=24)
	Total Recoverable	< 0.01 (n=16)	10. (n=5)[8]	95. (n=10)	98. (n=9)	103. (n=22)
	Dissolved	NA	NR	100. (n=4)	NA	101. (n=23)
Yttrium	Total	< 0.01 (n=16)	NR	106. (n=10)	110. (n=9)	101. (n=6)
	Total Recoverable	< 0.01 (n=16)	NR	101. (n=10)	103. (n=9)	100. (n=5)
	Dissolved	NA	NR	100. (n=4)	NA	101. (n=6)
Zinc	Total	< 0.01 (n=16)	13. (n=10)	94. (n=10)	96. (n=10)	102. (n=24)
	Total Recoverable	< 0.01 (n=16)	6. (n=10)	86. (n=10)	97. (n=10)	103. (n=22)
	Dissolved	NA	6. (n=4)	103. (n=4)	NA	103. (n=23)

Date Prepared: August 12, 1982

Table E-1 (Cont.)

FOOTNOTES

1 RPD = Relative Percent Difference = $\frac{X_1 - X_2}{X_1 + X_2}$ x 200, where X_1 and X_2 are duplicate values.

2 Spike Recovery = $\frac{X_s - X}{S}$ x 100, where X_s is the observed value of the spiked sample, X is the observed value of the sample, S is the true spike value. When values for X are below detection, 0 is used in statistic calculation.

3 Method and Reference Standard Recovery = $\frac{Ob}{T}$ x 100, where Ob is the observed value of standard and T is the known "true" value.

4 (n=_) = Number of measurements for a statistic.

5 NA = Not applicable to the dissolved phase because no sample digestion was conducted.

6 Spike less than 10 percent of sample concentration in one or more sample sets. Recovery data for these sets were not used in average calculations.

7 NR = Not reported; at least one of the two duplicates for all sample pairs were below the method detection limit.

8 One or more sets of duplicates were not used in average calculations for reasons cited in Footnote 7.